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The Design of Plywood Silos to Meet Farm Requirements *J. Dewey Long*

The Effect of Moisture Content in Drying Chopped Forage *L. G. Schoenleber, J. B. Shepherd*

Soil Erosion Studies—Detachment Hazard by Raindrop Splash *W. D. Ellison*

Flow of Air Through Chopped Hay in Mow Driers *H. D. Bruhn*

Hay Density in Relation to Various Drying Factors *Geo. E. Zerfoss*

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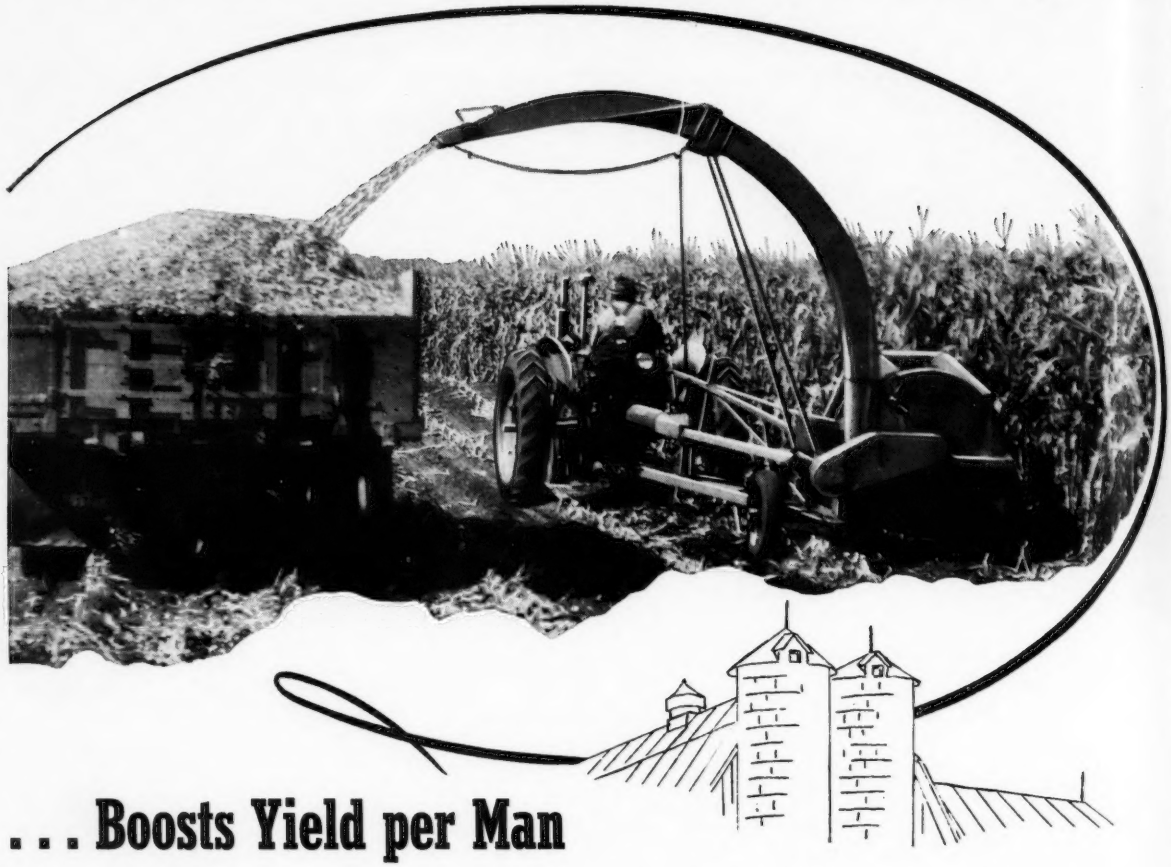
THE JOURNAL OF THE AMERICAN SOCIETY OF AGRICULTURAL ENGINEERS

Short Course for Corn



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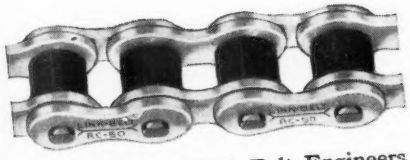

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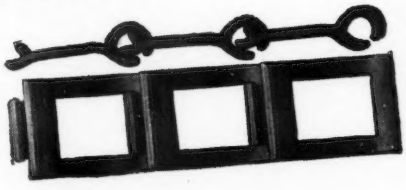

○ The trend towards cutting and storing green forage crops has created a growing demand for harvesting machines of a more rugged type than those commonly used for dry hay. The chain applications on Green Forage Harvesters are difficult and exacting. Link-Belt chains as designed by Link-Belt and Redpath engineers on the Redpath Green Forage Harvester have done an excellent job in assuring top productive capacity and reliability.

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RAYMOND OLNEY
Editor and Business Manager

EDITORIAL

Ideas on Chemurgy

FOLLOWING are some ideas on farm chemurgy with a definite bearing on agricultural engineering, which were brought out in the Farm Chemurgic Conference at Oklahoma City, March 25 to 29.

Progress in farm chemurgy provides opportunity for numerous small manufacturers of farm equipment and special tools. Arnold P. Yerkes pointed out this fact in addressing the Conference. He indicated the large farm equipment manufacturers are geared for efficient quantity production, and cannot attempt to develop and market numerous special items in demand only in limited areas, or with a small proportion of farmers in scattered areas. This is a field of opportunity for smaller manufacturers and job shops. The tool, equipment, machine, and fabricating industries are ready to provide the means of practicing chemurgy, but development and equipment problems should be put to organizations best adapted to meet the immediate and prospective demand for the specific items concerned.

* * *

With newsprint at $90 per ton, and scarce at that, and other grades of paper and pulp proportionally scarce and high priced, thoughts have turned to further use of farm produced fibers. At least one responsible paper mill engineer-executive believes there is an economic future for a farm or farm co-op size digester. The technical control involved would not be too complicated and the apparent advantages include the following:

Weight and volume of material to be shipped to the paper mill would be reduced to about one-fourth that of untreated pulp sources. Waste digester liquor would have considerable value as a fertilizer. The operation could be carried on in winter and other slack farm work periods.

* * *

Short supply lines were pointed out as favorable factors in the logistics of sound production economy and national security, as well as in military operations.

Continuing shortage of transportation facilities, together with technical progress in the separation and combination of basic materials, emphasize the pointlessness in many cases of giving long rides to materials which become waste at their destination, and to the abundant resources, such as water, which may be readily available near centers of use of consumer goods.

This favors increased horizontal diversification of farm production, a wider range of crops and livestock adapted to any particular farming area; and increased vertical diversification, with increased concentration, refining, preserving, sanitary measures, packaging, and use of low-value products at or near the farm. It further suggests a possible trend toward shipment of farm supplies such as feeds, fertilizers, and spray materials in more concentrated forms for dilution when necessary on the farm prior to use.

* * *

At the same time there appears to be little justification in the United States for encouraging the quantity production of farm crops outside of the areas to which they are ecologically best adapted for efficient production. The range of ecological adaptation of some crops can be extended by plant breeding, however, and the ecological classification of an area or field can often be upgraded economically by drainage, irrigation, fertilization, and other soil-building and environmental control practices.

* * *

Trainloads of water are being shipped in whole milk from dairy centers to distant centers of population. A major chemurgic economy is suggested by the theoretical possibility of removing some part of this water at or near the dairy farms and replacing it from the consumer's kitchen water tap. The problem, of course, is to remove the water economically in a manner which will not decrease the quality or palatability of the milk when it is rediluted to its normal water content.

If anyone has worked out a suitable way of doing this or is even working on the problem, his light is still under a bushel, so far as we are concerned.

One possible approach to this problem is suggested by the Kleinschmidt compression distillation apparatus developed for and used by the Navy to distill fresh water from sea water. It is a comparatively small unit, with large capacity, operating at high efficiency by reuse of latent heat.

Adaptation of this equipment to evaporate under partial vacuum, and at low enough temperature to avoid chemical changes in the milk constituents, appears to have possibilities.

* * *

Growing markets for furfural and alcohol and selective solvents, base materials in the manufacture of synthetics, and for other industrial uses, focus attention on their agricultural source materials, particularly those offgrade products often wasted.

Farm equipment and practices to improve the economy of production, harvesting, cleaning, grading, concentration, and packaging or bulk handling of such materials are continuing timely subjects for research and development.

At least one organic chemist believes that industrial alcohol has become or is about to become too valuable for other uses to be burned for fuel. That would settle the alcohol fuel disagreement definitely, and favorably for both sides of the controversy.

* * *

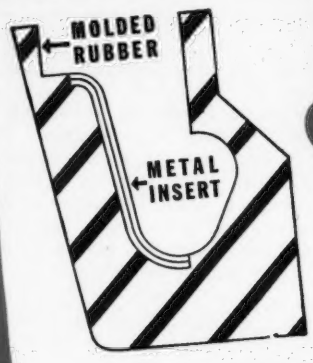
A speaker from the Midwest Research Institute hinted that some progress is being made in a project to devise a new low1cost method of soil stabilization for barnyards and other points where desired on farms, and that they are working in the direction of enabling farmers to do the job themselves with ordinary farm machinery.

* * *

Increasing the use of petroleum products for controlling weeds, insects, and plant diseases was indicated i na session with representatives from the peeroleum industry, which is interested directly in the higher income per gallon which such use will support. This points to higher income per gallon which such use will support. This points to further refinement of farm equipment for handling and application of these products.

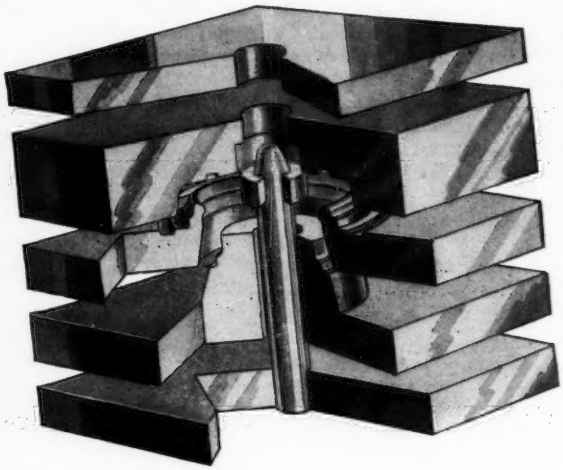
* * *

In a fiber session including consideration of the war-revived yucca possibility, and the problem-bedevilled ramie industry, it was hinted that the pressure release or explosion principle, in current use on wood chips, is showing further promise as applied to decortication and fiber separation. The future may conceivably see farmers or farm communities equipped with high-pressure, quick-release chambers for general-purpose use, in preliminary processing of a wide variety of farm-produced fibrous materials, and possibly for certain hulling operations and grain cleaning and seed treatments. *(Continued on page 220)*



"SIMPLE" PARTS

The relatively "simple" rubber-to-metal part indicated by the cross-sectional drawing above requires the complex, multiple-cavity mold illustrated at the right.



often demand

COMPLEX MOLDS

The "simple" rubber-to-metal part is not necessarily free of complications in producing it. As the above example illustrates, an intricate, multiple-cavity mold is required to produce the part that looks so "simple."

First consideration is the combination of conditions under which the finished part is to function. Next comes the design and manufacture of the mold to produce it. Then the correct compound of rubber or rubber-like material must be determined to meet both the molding and functional requirements. Exceptional precautions must be taken to prevent heat expansion from causing variations in the mold cavities, and often the mold cavities have to be registered individually with each other. Those and other related problems must be brought into "harmony" by modern techniques of the rubber industry. Briefly, it is a combination of "know-how" factors available here at "ORCO" that is causing an unprecedented demand for our services from a wide diversity of industries.

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AGRICULTURAL ENGINEERING

VOL. 28 MAY, 1947 NO. 5

Designing Plywood Silos

By J. Dewey Long

FELLOW A.S.A.E.

ANY building material supplier who offers his product to a specialized building market should present proof of its successful use under actual operating conditions in full-sized pilot models.

This is especially true of a structure such as a silo which must function under the most extreme conditions to be met by any farm building. The requirements of smooth walls to prevent air pockets; of tight walls to prevent air infiltration and unsightly leakage; of structural integrity against the appreciable ensilage pressures, against shrinkage and swelling stresses imparted by variable moisture content, and against wind pressures; and of durability against the moisture, acid, and alcohol of ensilage juices as well as common structural hazards are well known to agricultural engineers.

In its agricultural market research program the Douglas Fir Plywood Association has recognized the necessity for actual silo erection and use experience. A number of successful silos built during the past six years have proven that fir plywood offers definite advantages for such construction.

Glued plywood makes a very rigid, smooth, tight, and durable construction. It is not attacked by the acid and alcohol components of the ensilage juices; six years of use have indicated that to some extent these may be considered a preservative for the wood as well as for the ensilage. Moisture changes do not result in destructive shrinking and swelling. A moisture-resistant paint coating which is also resistant to mild acids and alcohol on interior walls, and a good exterior paint on the outside are recommended, however.

The light weight and large area of the panels contributes to savings in both transportation and erection. Either site erection or prefabrication is possible. While parts prefabrication has not yet been proven in a large silo, some fabricators are considering factory construction of a 12-ft diameter by 32-ft cylinder, trucking it to the farm site and pulling it up to a vertical position on the foundation.

MATERIALS

Only the exterior-type Douglas fir plywood should be used where the moisture content of the panels may exceed 20 per cent, as in silo walls. Since the phenol formaldehyde resin adhesive used in this type of panel was developed only about 12 years ago, it is not possible to cite long-time use experience as evidence of durability. Ten years weather exposure tests, accelerated laboratory tests, and wide war usage, as well as the six-year silo record, indicate a useful life for such a structure under reasonable conditions of at least 20 years. Each exterior-type panel carries the brand or stamp "Ext. DFPA", with the possible addition of an individual mill trade mark.

The glue used for the secondary or fabrication gluing of the panels to the framework must also be insoluble and inert to acid and alcohol attack. Casein glue, which is only highly

This paper was presented at the fall meeting of the American Society of Agricultural Engineers at Chicago, Ill., December, 1946, as a contribution of the Farm Structures Division.

J. DEWEY LONG is director of education and market research, Douglas Fir Plywood Association, Tacoma, Wash.

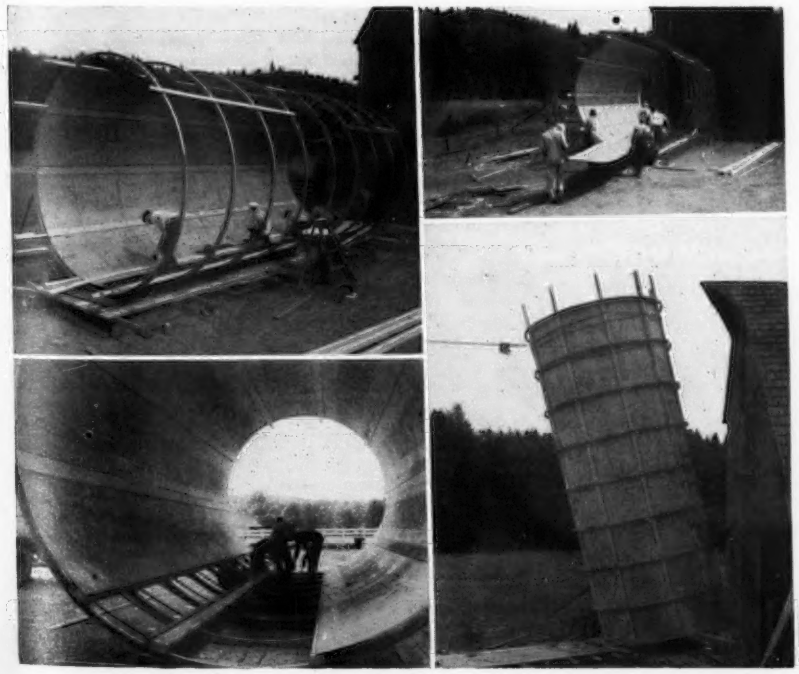


Fig. 1 *Upper Left:* Prefabricated plywood poultry silos were built at the State College of Washington in 1944. Design 1 consisted of a curved-door section and ¼-in thick, exterior-type fir panels edge-lapped 3 in, nailed, and glued. *Upper Right:* The glued panel assembly for Design 1 was rolled into a cylinder and glued inside wood hoops at either end and covering the center joint. The completed silo was approximately 5x12 ft in size. *Lower Left:* Design 2 of the SCW poultry silos consisted of prefabricated curved sections 4x12 ft in size and a 2-ft wide door panel with built-in, vertical sliding doors. Asphalt mastic was spread on the joint before the sections were bolted together. *Lower Right:* Designs 2 and 3 of the SCW poultry silos. Design 3 (in foreground) is octagonal in shape with construction details similar to those in No. 2. Plywood diaphragms are placed over the top of the ensilage and weighted to prevent spoilage

moisture resistant, not waterproof, was used in a group of three silos built three years ago in a humid climate. No sign of deterioration has occurred, but other use experience makes the ultimate life of casein glue under such exposure doubtful.

Urea formaldehyde resin has certain desirable working characteristics and is properly termed a waterproof adhesive. Its use in silos extends over four years with no signs of distress. Under salt water attack, however, and under other exposure conditions not fully defined at the present time the urea resins have been known to craze and lose their bonding strength.

The resorcin formaldehyde resins originated just prior to the war and enjoying wide usage and development for critical military uses, are believed to be the most desirable for silo fabrication. The first all-plywood silo built five years ago was fabricated with such an adhesive. Resorcin is a petroleum product similar to phenol. Its formulation with formaldehyde results in a resin which polymerizes, or "sets up", at a 75F (degrees Fahrenheit) minimum temperature. The phenol formaldehyde formulations require appreciably higher operating temperatures.

The resorcin formaldehyde resin is in limited production, commands a higher price than the casein or urea adhesives, and is usually available under current marketing conditions only from the manufacturer. Several concerns produce the product with slight variations in formulation. It is usually supplied in liquid form with a catalyst which must be mixed on the job prior to use. The working life of the mixed adhesive depends upon the proportion of resin and catalyst, as well as temperature. The setting time for the adhesive also depends upon proportioning and temperature, becoming appreciably shorter as the latter is elevated above 75F.

With nailed assembly for contact pressure the joint is held sufficiently firm to permit careful moving immediately after fabrication. At 75F at least two days should elapse before placing any appreciable loads on the joint and major structural loads should be delayed for at least a week. Nail spacing should be close for adequate contact pressure; two-inch spacing is recommended. Nailing pressure is not as positive as that from a rigid press frame.

Glued fabrication is like welding in that some intelligent knowledge of the materials and techniques is required. For this reason it cannot expect widespread acceptance until the glue manufacturers develop service facilities and exert some effort to educate field mechanics. Factory manufacture of some type of prefabricated design is the most logical point of introduction. Where skilled supervision is available for site erection the development of adequate structural joints is a relatively simple procedure.

STRUCTURAL DESIGN

Safe unit working stresses for Douglas fir plywood are given in "Technical Data on Plywood", section II, (Douglas Fir Plywood Association, 1942). These values are taken from the USDA Forest Products Laboratory bulletin, "Approximate Methods of Calculating the Strength of Plywood". Many of the stress values were revised upward in October, 1946, as a result of more extended test data. The revised values are used in the structural analysis examples given later in this paper.

The complete structural design requires consideration of foundation stability, anchorage of superstructure to base, vertical and lateral wall loading, and wind pressure overturning moment.

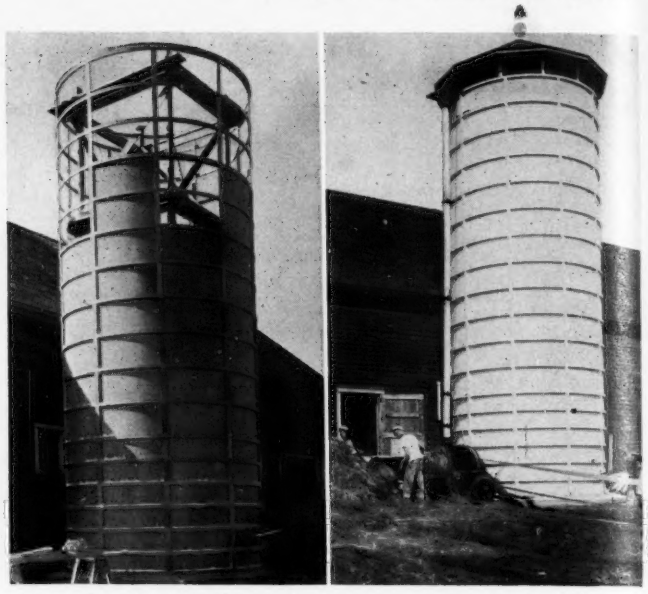


Fig. 2 *Left:* Wood-hoop plywood silo erected near Seattle in 1942, showing the interior scaffolding which also serves to hold the hoops in position until panels are applied. *Right:* The completed Seattle silo. The glued plywood assembly makes a very rigid and tight construction. Hoops cover the horizontal panel joints and battens the vertical joints

TYPICAL FIELD TESTS

As a first step toward prefabricated silo designs, the Douglas Fir Plywood Association cooperated with the University of Tennessee in 1942 in the erection of an octagonal design 8x24 ft in size (See AGRICULTURAL ENGINEERING, p. 58, February, 1944, and p. 431, September, 1946.)

A second project initiated with the State College of Washington led to the erection of three 5x12-ft poultry silos of different prefabricated designs in 1944. These required varying amounts of site fabrication.

In the first of these three designs the door section was shop fabricated in curved 8 and 4-ft lengths using ¼-in, 3-ply panels and glue-laminated door framing (Fig. 1). Flat panels of the same thickness and length were edge-lapped 3 in, glued and nailed with ¾-in nails 2 in on centers which were immediately clinched for additional pressure. The curved door sections were attached at one end of each panel. After 15 hours for the glue set, the large flat panels were rolled up and held in cylindrical form with a rope. Shop-formed, glue-laminated hoops 4 in wide were glue-nailed at either end and at the joint between the 4 and 8-ft lengths. The approximate time required for site assembly, construction of the concrete foundation, and fastening the stud anchor straps to silo wall and foundation was 32 man-hours.

The second poultry silo design was fabricated entirely in the shop and required only bolting together on the site. The fabricated parts consisted of a flat door panel 2x12 ft, and four curved wall panels each 4x12 ft. Vertically sliding doors of ⅜-in plywood were placed in the door panel. The wall panels were ¼-in plywood nail-glued to segments of laminated wood hoops. The 2x3-in studs at either side of the curved wall panels were bored for ⅜x4½-in machine bolts spaced 6 in apart at the bottom and 16 in at the top. An asphalt roofing cement was troweled on the contact faces of the vertical studs prior to bolting. The site assembly, including construction of a plywood floor panel on skids and fastening the structure to steel anchors driven in the ground, required approximately 22 man-hours.

The third small silo was octagonal with 2x12-ft flat panels,

one of which carried ⅜-in plywood doors hinged to swing in. To avoid excessive deflection the flat wall panels were ⅜ in thick. Two-by-three-inch studs at the vertical edges and 2x4-in plates flat against the panels at top and bottom constituted the framing. The structure was assembled by bolting as in the second design. It was set on a mud sill with water-resistant paper on top of a gravel fill for a floor. Complete assembly required approximately 18 man-hours.

Wood Hoop Designs. Silos formed by wood hoops, glued and laminated, with plywood panels glued and nailed to their inside faces are probably the easiest to design and erect on the site. The tight glued joints of the hoops and silo wall exclude moisture and have shown no evidences of rot sometimes found in other wood hoop silo types.

The first silo of this type, built north of Seattle, has been used five years for grass ensilage (Fig. 2). No sign of deterioration or difficulty of any kind has been experienced. The glued assembly of the 12x32-ft cylinder makes a very rigid structure. Correct design of the foundation and anchor ties to the foundation enables such a structure to withstand severe wind loading successfully without diagonal ties or other bracing. Torsion ties applied on the initial structure in accord with local tradition are unnecessary for this design. A wind storm which wrecked or severely damaged one hundred other silos in the vicinity left no mark on the plywood structure.

The cross-sectional area and vertical spacing of the hoops are designed for the anticipated lateral pressure according to conventional structural design practice. The vertical load carried by the thin plywood wall theoretically induces a tendency for it to buckle between hoops, but in a circular structure it is restrained both by the curvature and the lateral pressure of the ensilage. The compression load on the bottom edge of the plywood panels requires consideration but lies within the safe limit where ⅜-in thick panels are used for silos of ordinary size. The wood hoop glued to the bottom adds additional bearing area.

In the initial project wood hoops were laminated from ⅜x2⅝-in fir battens, spacing end joints at least 2 ft apart. Five laminations were used for the hoops for the lower 16 ft of the structure, and four laminations for those above. Hoop spacing was 16 in for the lower 8 ft and 24 in for the remaining height. Three-eighths inch thick 4x8-ft panels placed vertically were glued and nailed inside the hoops. The staggered horizontal joints were covered by hoops, and vertical joints by 2x4-in battens cut between hoops. Prior to assembly the ends of the spacers were coated with white lead paste to exclude moisture. The roof was raised 2 ft above the walls, covered with triangular plywood segments, and painted.

An inexperienced crew, under supervision, fabricated the 19 hoops and erected the silo in 24½ man-days. The structure was painted with exterior lead and oil paint and coated with asphalt on the interior. Construction costs were as follows:

Labor	$263.54
Painting (material and labor)	100.07
Plywood	140.57
Glue	23.00
Other materials	226.68
	$753.86

An experienced crew and design simplifications would effect material cost reductions.

Three silos of this general design, 14x28 ft in size, are located on a dairy south of Seattle. The large size of the hoops, which were fabricated at a mill, constituted a transportation problem. To overcome this the hoops were cut in halves and bearing blocks glued at the ends of the segments. At the site ⅝-in bolts through the blocks brought the hoops to their original shape and strength.

The largest plywood silo which has been constructed is a 25-ft diameter, 32-ft high wood-hoop structure erected near Sumner, Wash., in 1946 (Fig. 3). Glued wood hoops 2x3 in in size were laminated on the site from ½x3-in spruce. These were spaced 16 in for the bottom eight feet and 24 in for the remaining height. They were lined with ⅜-in plywood panels placed vertically with staggered horizontal joints supported by the hoops. Vertical joints are covered with 4-in strips of ¾-in plywood between the hoops and glued and nailed to the panels. A second layer of ⅜-in panels around the bottom 8 ft contributes additional strength. While this structure is overstressed theoretically, it has successfully withstood the first season's use.

This silo was built by the farmer with a limited amount of technical assistance. Construction of the 19 hoops was the most time-consuming part of the erection. Approximately three weeks of short-hour working days between chores was required for this part of the project. Two local carpenters were hired and the silo completed in eight days. The structure was left open at the top and painted on the exterior with marine paint. Materials and labor for the complete job cost about $1,000.

Stressed Plywood Design. A second design erected in 1942 at the University of Tennessee was circular in shape and 8x24 ft in size. It is noteworthy in that the plywood wall itself is stressed by the lateral pressure.

One-quarter inch thick 4x8-ft panels were placed vertically with horizontal joints staggered. Eight-inch-wide battens of the same thickness of plywood were nail-glued at 2-ft spacing around the outside to coved the horizontal joints and serve as lateral reinforcing. The battens were cut with the face grain running the long dimension to gain the advantage of having the two face veneers act in tension. A little difficulty in bend-

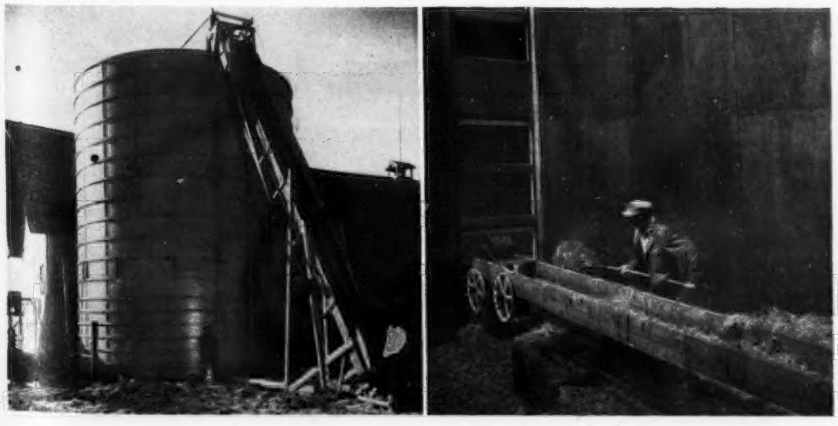


Fig. 3 *Left:* A 25-ft diameter 32-ft high plywood silo erected in 1946. *Right:* Interior of the 25-ft diameter silo, showing the staggered panel joints and door opening. A movable horizontal conveyor saves labor in feeding out ensilage

ing these battens to the 4-ft radius while working on scaffolding was the only construction problem. Similar battens 6 in wide were nailed-glued over the vertical joints.

Oak door jambs, 4x4 in in size, were fastened with steel bolts across the continuous door opening. Short 2x4-in studs were placed around the bottom of the silo wall to provide a more rigid fastening for the steel strap foundation anchors.

Another "stressed-skin" design and construction study made use of scarf-jointed or "jumbo" panels (Fig. 4). These were 7/16-in, 5-ply unsanded panels 4 ft wide and 30 ft long. The design was predicated on these panels and the glued vertical fabrication joints carrying the lateral loading without horizontal reinforcing.

The large size and flexibility of the large panels indicated that the 12x30-ft cylinder could be fabricated most easily in a horizontal position. In order to secure a cylindrical shape laminated wood hoops were built and placed vertically 45 in apart on a platform adjacent to the concrete foundation. Three by four-inch studs were placed lengthwise inside the hoops with their inner faces 4 ft apart on the 12-ft diameter arc. The studs were bolted and glued to the hoops.

To facilitate bending the panels to the desired curvature, they were stacked on the barn floor with a row of wet grain sacks between each layer. Since successful gluing requires dry wood surfaces, the sacks were placed down the center keeping the panel edges dry. After two days wetting, the panels were carried inside the hoops, weighted to the desired curvature, and glued and nailed to the studs. A 6-in batten of ¼-in plywood was glued and nailed over the inside of the joint between panels to give the required glue joint area. The structure was rotated on the platform after each panel was in place so the succeeding panel position was horizontal. Five-eighths-in steel bolts were placed across the continuous door opening, and ¾-in plywood doors hinged to swing in.

Three days were allowed for the glue set before erection. Since the silo position was at the end of the barn the hay rope was tied to the top end of the cylinder, the ends of the structure were stiffened by internal blocking, and it was pulled erect on the foundation. Steel anchor straps were bolted to the 3x4-in studs with their lower ends cemented in holes which had been cored out when the foundation slab was poured.

The structure was painted on the interior with an experimental resin seal. It was filled immediately with grass ensilage so painting of the exterior was deferred until it was empty and the walls dry.

About 22 man-days between chores were devoted to the project by the farmer and his son. Three neighbors were hired on occasion; supervision and some labor were donated by the college extension service and the plywood association. The large, scarf-jointed plywood panels carried a premium price compared to the standard size panels, but permitted design and construction economies. The following summary of cash costs was collected by the county agricultural agent.

Gravel and cement	$ 14.29
Plywood (including hoops, chute, and roof)	312.00
Studs	41.00
Hardware and fittings	67.10
Hired labor	75.00
Hauling	15.00
Total	$524.39

STRUCTURAL ANALYSIS

The structural analysis for the latter design, using the large scarf-jointed panels, will illustrate the general design procedure for a glued plywood structure of this type.

Unit Stress Values. Unit stress values for fir plywood are available from either the USDA Forest Products Laboratory or the Douglas Fir Plywood Association. The safe unit values used in this design are those for the Sound One Side grade where the moisture content of the panels will exceed 16 per cent. They apply only to those veneers in the panel assembly which are acting.

Compression parallel to grain (5 ply)	1100 psi
Tension perpendicular to grain of face plies	1500 psi
Rolling shear in plane of plies and perpendicular to face grain	72 psi

Characteristic structural properties of different plywood constructions and thickness are given in "Technical Data on Plywood", available from the plywood association. These include the cross-sectional areas of the lengthwise and crosswise veneers for different panel thicknesses and assemblies.

Silo Dimensions. Since the silo wall includes nine 4-ft-wide panels placed vertically and a 2-ft continuous door open-

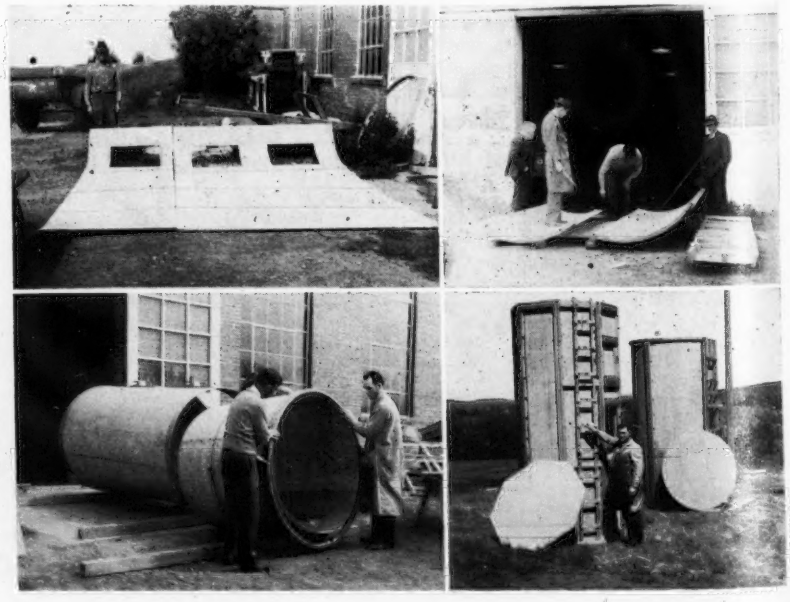


Fig. 4 *Upper Left:* A "stressed skin" plywood silo built in 1946 made use of 4x 30-ft scarf-jointed panels. The structure was fabricated in a horizontal position and adjacent to the concrete foundation. Laminated wood hoops were used as forms; they were not considered in the structural design. *Lower Left:* The jumbo size panels were carried inside the framework and glued and nailed to the studs. The structure was then rotated on the platform to receive the next panel. *Upper Right:* Interior view of structure showing preparation for last panel. Plywood gussets over the vertical panel joints and widened door jambs give the required glue joint area to carry the ensilage pressure. Steel bolts transmit the load across the door opening. *Lower Right:* After allowing time for the glue set the structure was pulled erect on the foundation. Roof and chute were added later

ing, the perimeter of the inner surface is 38 ft; the interior diameter is 12.1 ft. Any slight deviations or assembly tolerances can be readily absorbed in the doorway width. Panel edges are glued and nailed at the centerline of 3x4-in studs placed flat against the outside wall. Hoops laminated of six thicknesses of ⅜-in plywood strips cut 2 in wide lengthwise of the panel have a cross section of 2x2¼ in and an interior diameter of 12 ft 7.4 in. They are designed only for a reasonable rigidity to form the circular shape and not for lateral reinforcement. Hoop spacing is 45 in, with the lower hoop raised 3 in above the base for drainage.

Foundation. An annular concrete slab with 10-ft inside and 13-ft outside diameters, and extending at least 12 in above and 6 in below grade, is poured in place. The top surface must be smooth and level, except that the inner and outer 6 in may be sloped to drain. Four ⅜-in reinforcing rods bent to circular shape and with the ends lapped and wired are buried in the four corners 2 in from the surface. An intermediate concentric ring and 18-in radial rods with bent ends, spaced approximately 6 in apart, should be placed 2 in above the bottom.

Since steel anchor straps extending above the slab surface would interfere with the erection of the prefabricated silo, they are not poured integral with the slab. Instead tapered holes with 4x4-in top dimension and 8x8-in bottom dimension are cored in the slab. They are centered on a 6-ft, 2¼-in radius to permit the strap anchors to be bolted to the side of the 3-in (net 2⅝-in) surfaced studs. Bolting to the side rather than on the outer face avoids interference with the lower wood hoop. The holes are spaced on 4-ft centers around the perimeter with the 2-ft opening properly located for the desired door position.

SUBGRADE MUST BE UNIFORMLY COMPACTED

Care should be exercised that the subgrade is of uniform compaction and that water from roof drip or runoff will not cause uneven softening and induce differential settlement. Subdrainage through the open center of the foundation ring will be inadequate. Two or more 2-in diameter pipes should be placed horizontally through the concrete or the top of the slab scored with two or more 2-in wide and deep radial V grooves.

Vertical Load. Assuming that 40 per cent of the total ensilage weight will be carried as a vertical load on the silo wall, and that a 12x30-ft structure has a 75-ton capacity, the compression load on the bottom of the wall will be 30 tons.

The end area of the three parallel plies in 7/16-in, 5-ply rough (unsanded) panels is given in "Technical Data on Plywood" as 3.25 sq in per foot of width. Substituting values in the typical unit load formula, $S = L/A$, the unit load is found to be 512 psi.

This anticipated load is less than half the unit safe compressive stress of 1100 psi, indicating that the plywood walls alone will carry the vertical loading. Adding the 87.5 sq in additional bearing area of the 10 studs indicates an induced stress for walls and studs acting together of 293 psi.

Subgrade Pressure. Assuming a weight of one ton for the plywood super-structure and 6 tons for the foundation gives a total load, including the compression load on the wall, of 0.68 ton per square foot on the subgrade. This is well within safe limits for any reasonable soil condition. Soil freezing, with resultant heaving, is not a factor in western Washington where this structure was erected.

Lateral Bursting Pressure. When the 4x8-ft, 7/16-in thick plywood panels are placed vertically as in this design, the two 1/12-in thick crossband veneers with horizontal grain direction resist the bursting pressure in tension. They have a cross-sectional area of 2 sq in per foot of height and safe unit working value for the grade of 1500 psi, or a total safe tensile load of 3,000 lb per foot of silo height.

From the conventional formula for tensile stress in the walls of a vertical cylinder, and assuming the lateral pressure for grass ensilage as 20 lb per foot of depth and the settled depth of the silage as not exceeding 27 ft, the design load is computed as 3,267 lb maximum per foot of height. For the conservative working stresses and loading assumptions, the 267-lb overload is not considered hazardous.

Vertical Glued Joints. Since the plywood walls are designed to carry the entire ensilage pressure without benefit of framing or hoop reinforcing, transmitting the lateral pressure across the vertical panel joints will require glued connections. Such loads applied in the plane of the panel face set up "rolling" shear strains in the veneers both at the joint face and within the body of the panel. These are most pronounced in the contact faces and decrease progressively through the panel thickness.

The glued width of each panel face required to transmit the 3,267-lb maximum load (272 lb per inch of glued joint length) is secured by dividing this value by the safe unit shear value. The required width per inch of height is thus determined to be 4 in. Each half of the surfaced stud width of 3⅝ in provides 1.8 sq in per inch. The additional area is provided by a glued ¼-in thick plywood gusset plate on the inside of the joint.

DIFFICULTY SPRINGING PANELS TO CURVATURE

Since some difficulty was anticipated in springing the heavy panels to the curvature necessary to secure full contact with the stud face, the width of the gusset was made 6 in. For each inch of joint length this provides a total of 4.8 sq in of glued contact surface for each of the abutting panels.

The ¼x6-in gusset plate is continuous from top to bottom. It does not interfere with settlement of the ensilage. No allowance is made for the additional strength imparted by the 6d common nails spaced 2 in on centers used to secure contact pressure between panels and studs until the glue sets. Unless the interior wall of the silo is waterproofed, they will eventually rust.

Door Opening. At the door jambs where a gusset is impossible, it is necessary to increase the jamb width to secure the required glued contact area. This may be accomplished either by using 6-in wide jambs or by gluing 2-in scabs to one edge of the 4-in members.

Transferring the lateral pressure across the door opening requires the use of bolts through the jambs. On 22.5-in centers these fall behind hoops and at the horizontal door joints, avoiding interference with the door openings. Since they may be bent to provide a 3-in clearance between them and the door, they also serve as the ladder.

The maximum load is carried by the second bolt from the bottom. Here the unit load is 3,000 psf and the supported height 1.875 ft, giving a total load of 5,625 lb. A ⅝-in round steel rod with 20,000 psi allowable stress gives the required 0.3 sq in cross-sectional area required to carry this load.

Taking the safe compression stress of the bolt washers against the door jambs as 500 psi, the required contact area is found to be 11.25 sq in. Strap steel washers ⅜x2¼x5 in provide this area.

Wind Load. Wind pressure, subjecting the structure to torsion and overturning, is most critical when the silo is empty.

Forest Products Laboratory research has shown that ¼-in plywood glued to conventional framing is almost 15 times more rigid than nailed shiplap. Experience also has demonstrated that the rigidity of the large panels glued into cylindrical shape is ample to resist wind-induced torsional stresses without the addition of spirally wound cables or other wind bracing.

Overturning is resisted by the weight of the structure and the foundation anchor ties. The inertia moment, which is the product of the silo weight and its radius, is 12,000 ft-lb.

Maximum unit wind pressure is assumed to be 15 lb per sq ft. Using a shape factor of 0.6 the total pressure is 3,240 lb, and the overturning moment with the pressure applied at midheight is 48,600 ft-lb.

The difference, 36,600 ft-lb, will be held by the anchor ties. Assuming that under the most critical wind direction two of these will be acting at 5.5 ft from the center line and two at 3 ft, the resisting force is computed as 2,150 lb in each tie. Using 20,000-lb steel the required cross-sectional area is 0.108 sq in. Steel straps ½x2 in, with 1 sq in area, have an ample factor of safety even when badly rusted. The bottom ends of the anchors should be bent back at 180 deg.

Lag bolts fasten the anchor ties to the side of the studs. The allowable lateral load parallel to the grain for lag bolts screwed through metal plates into the side grain of Douglas fir framing is given by the formula $P = 2280\ D^2 f$. Using ½-in lag bolts, the allowable load on each becomes $P = 2280\ (0.5)^2\ 1.25 = 712$ lb. To carry the 2150-lb total load, therefore, will require three lag bolts for each anchor tie.

The inertia moment for the concrete foundation slab is 78,000 ft-lb. The combined value for foundation and superstructure is 1.85 times the computed overturning moment.

After the studs are properly located with respect to the cored holes in the foundation the anchor ties are bolted to them and grouted in place. Diagonal ties fastened to the top of the silo should be left in place to hold it against winds for at least 5 days until the concrete grouting has set.

REMODELING

The exterior-type fir plywood has also proved its usefulness in silo reconditioning. Many stave, crib, Gurler, and other types of wooden silos which have served twenty to thirty or more years have about reached the end of their usefulness. Pulling these erect, replacing any broken or rotten sections, cutting them off a foot or more at the bottom if necessary, reconditioning the reinforcement and lining them with ¼-in exterior-type fir plywood may add another 10 to 15 years of life. A careful preliminary examination must be made, of course, to make certain they are worth the moderate repair cost.

After the old shell has been reconditioned the 4x8-ft plywood panels are nailed to the interior wall in 8-ft horizontal courses. The first panel is nailed to one side of the door and sprung to the silo curvature. Nails should be 4d or 6d size, depending on the wall thickness, and should be spaced approximately 6 in apart along the panel edges and 12 in apart vertically through the center, nailing into each stave or board of the old wall. Succeeding panels in the first course may be butt-jointed against those previously applied or may overlap them 2 in. The latter procedure is desirable where the structure is not straight or of uniform diameter.

Successive courses are applied in similar manner, with the bottom panel edges butt-jointed against those in the course below. No horizontal ridges are formed to interfere with settlement of the ensilage. Renailing may be required in 3 to 5 years if the nails are badly corroded by the silage juices.

If desired, the plywood walls may be covered with asphalt or some other acid-resistant paint to help prevent rusting of the nails. Exterior-type, ¾-in panels may be cut and fitted for tight doors, and ⅜-in panels may be used for the roof and chute.

The advantages of the plywood wall lining are the rigidity and additional reinforcement it imparts to the structure and the tightness of the wall essential to the storage of ensilage.

Design of Barn Hay-Curing Systems for High, Narrow Mows

By A. W. Clyde

MANY old barns in this part of the country are divided into haymows 18 to 20 ft wide, with a drive-in or barn floor between mows. The hay mows are often 15 to 20 ft deep, and common practice has been to fill one mow completely before starting on another. Such a haymow often has one side entirely open, and on the other sides the walls with projecting timbers and cracks do very little to confine air to the mass of hay. When air is admitted to the hay near the floor, much of it finds easy paths out the sides, and very little reaches the hay near the top. Even if the air could be confined so that most of it would be forced through the upper layer of hay, it is doubtful if that would be good practice, because of the resistance encountered. Blowing air through 15 to 20 ft of hay merely to dry the last foot seems a wrong practice, particularly if the power unit is limited in size.

The accompanying illustration shows a duct which was used last season with two lots of hay in a high narrow mow. It replaced a system of three low ducts running lengthwise of the mow. The new duct is similar to one described by Ramser and Lehmann in AGRICULTURAL ENGINEERING for April, 1946, their installation being used for drying a stack of hay. Benefits expected from the single high duct were:

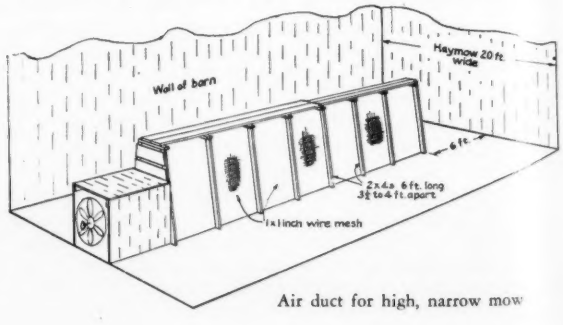
1 Better air distribution. This mow could be filled to a depth of 14 ft. The duct is a little over 6 ft high; therefore, air has to travel through approximately 8 ft of hay in going either upward or out to the sides.

2 Low resistance to air flow. It was believed that the resistance would be low, provided a large area was allowed for air to enter the hay. Low resistance was wanted to permit a large air flow with a 3-hp electric motor.

Experience with two lots of alfalfa indicate that both of these expected benefits were realized to a considerable extent. There was less trouble with slow-drying spots than had been the case with the low ducts. Resistance and air flow conditions were definitely better. Lots of hay which seem comparable gave the following results with the two duct systems, a little over 3 hp being used in each case:

	Low ducts, 1945	Single high duct, 1946
Resistance, inches of water	0.70 to 0.75	0.5
Air flow, cfm	14,500	18,000

Some attention to the management of the single high duct is required when the mow is only *(Continued on page 210)*



Air duct for high, narrow mow

This paper was presented at the 3rd Barn Hay-Curing Conference sponsored by the American Society of Agricultural Engineers at Chicago, Ill., December, 1946.

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Effect of Moisture Content on Drying Requirements and Nutrient Losses in Chopped Forage Dried on Mow Hay Finishers

By L. G. Schoenleber and J. B. Shepherd
MEMBER A.S.A.E.

WITH development of labor-saving machinery for chopping forage and use of mow hay finishers to complete the curing of chopped forage in the barn, it is necessary to know at what moisture content the forage should be stored for barn drying for best results.

It is generally agreed that chopped hay must have a lower moisture content than long hay for safe storage[1,2,3,4]. However, no information has been published on the losses of nutrients occurring in chopped forage of different moisture contents when drying is completed with a mow hay finisher installation.

The work herein reported is a part of an extensive forage harvesting research program of the U. S. Department of Agriculture being conducted at the Agricultural Research Center at Beltsville, Md., cooperatively by the Bureau of Dairy Industry, Bureau of Plant Industry, Soils, and Agricultural Engineering, and the Production and Marketing Administration.

On August 8 and 9, 1945, two comparable lots of green forage were cut from the same field and at the same time. Each lot of forage was partially field-cured to different moisture percentages. It was chopped at the time of storage and drying was completed on separate but identical mow hay finishing installations located in the same barn. The drying installations were of the side main duct and tapered laterals. The objectives were to determine the effect of a high and a low-moisture content on the time required to dry to a safe moisture content for storage, the blower and electricity requirements for drying, the chemical composition of the forages produced, and the losses of dry matter and feed nutrients sustained.

The forage consisted of third cutting mixed alfalfa, ladino clover, and grass. It was cut with a power mower and raked into windrows in the usual manner, using a side-delivery rake. Every other windrow was selected for the high-moisture lot. Similarly, every other windrow was left for the low-moisture lot. The forage in both lots was considered representative of the field.

After field drying to the desired moisture content, each lot of forage was picked up with a hay loader and hauled to the barn in wagon racks where it was run through a silo filler and blown directly onto the drying installation. Each lot of forage was chopped at a theoretical cut of 3 in and distributed uniformly to a depth of 5 ft without being tramped on. The high-moisture lot consisted of 9.48 tons of forage with an average moisture content of 39.2 per cent. The low moisture lot consisted of 7.67 tons of forage with an average moisture content of 32.9 per cent (Table 1.)

TABLE 1. CONDITION OF THE FORAGES AND REQUIREMENTS FOR DRYING TWO LOTS OF CHOPPED HAY OF DIFFERENT MOISTURE CONTENTS

Measurement		High	Low
Weight of forage placed on drier	tons	9.48	7.67
Average moisture content (wet basis)	per cent	39.17	32.86
Average moisture content of top foot when drying completed (wet basis)	per cent	16.98	16.94
Weight of forage taken off drier	tons	5.94	5.42
Average moisture content of hay when removed	per cent	14.20	10.65
Height of hay in mow when put in	ft	5	5
Height of hay in mow when dried	ft	4	4
Time required for drying	days	6.3	4.2
Time of blower operation	hr	97	68.5
Air delivered per square foot, per minute	cu ft	15-16	15-16
Consumption of electricity	kw-hr	320	195
Consumption of electricity, per ton of dried hay	kw-hr	53.8	36.0

Drying was done using outside unheated air which was supplied to each lot of forage at the rate of 15 to 16 cfm per sq ft of floor area. The blowers of the driers were operated during the same periods of time the first few days except for one period of less than an hour. The blowers were shut off during the period of the second day that forage was being placed on the driers. On the third day, August 10, and thereafter the blowers were shut off at night except for intermittent operation to keep the forage from heating. The hours of fan operation are shown by Figs. 1 and 2.

The weather conditions during this period were not particularly favorable for barn drying, but were about normal for this locality. The humidity stayed up above 70 per cent during a 12 to 16-hr period each night, and dropped down between 40 and 50 per cent in the daytime. Atmospheric temperatures ranged from nighttime minimums of 60 to 67 F to daytime maximum of 77 to 86 F.

When the drying was completed, both lots of hay had settled to a depth of approximately 4 ft. The top foot of the high-moisture lot had an average moisture content of 16.98 per cent, and the low-moisture lot an average moisture content of 16.94 per cent. The high-moisture lot contained 5.94 tons of hay with an average moisture content of 14.2 per cent.

This paper was presented at the Third Barn Hay-Curing Conference sponsored by the American Society of Agricultural Engineers at Chicago, Ill., December, 1946.

L. G. SCHOENLEBER is agricultural engineer, farm electrification division (BPISAE), and J. B. SHEPHERD is dairy husbandman, division of nutrition and physiology, Bureau of Dairy Industry, U. S. Department of Agriculture.

AUTHORS' NOTE: The authors desire to give credit to the following persons who cooperated in this study: R. E. Hodgson, L. A. Moore, H. G. Wiseman, and C. G. Melin, Bureau of Dairy Industry, and W. H. Hosterman, Production and Marketing Administration, U. S. Department of Agriculture.

*Superscript numbers refer to appended references.

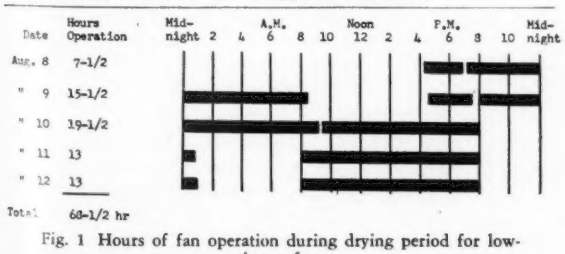

Fig. 1 Hours of fan operation during drying period for low-moisture forage

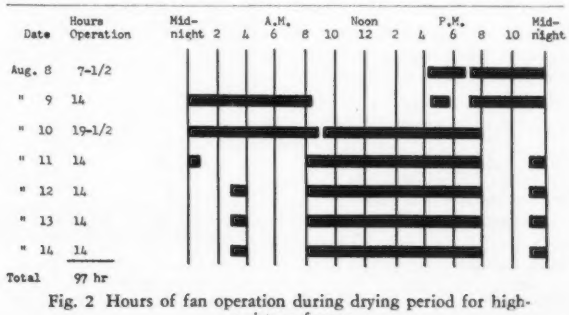

Fig. 2 Hours of fan operation during drying period for high-moisture forage

TABLE 2. CHEMICAL COMPOSITION OF THE DRY MATTER FROM TWO LOTS OF CHOPPED FORAGE OF DIFFERENT MOISTURE CONTENTS DRIED ON MOW HAY FINISHERS

Time analyzed	Protein, per cent	Fiber, per cent	Ether extract, per cent	Nitrogen free extract Sugar, per cent	Nitrogen free extract Total, per cent	Ash, per cent	Carotene, micrograms per gram
High-Moisture Forage							
Put on drier	18.59	27.88	1.77	5.44	45.08	6.68	113
Taken off drier	18.35	27.93	1.90	4.69	44.88	6.94	41
Low-Moisture Forage							
Put on drier	18.42	28.82	1.74	5.35	44.47	6.55	100
Taken off drier	18.42	27.63	1.67	5.05	45.53	6.75	47

The low-moisture lot contained 5.42 tons with an average moisture content of 10.65 per cent.

The length of time required to dry the chopped hay was 6.3 days for the high-moisture and 4.2 days for the low-moisture lots. For drying each ton of dried high-moisture hay 53.8 kw-hr of electricity were required. For drying each ton of dried low-moisture hay 36.0 kw-hr were required.

The chemical composition of the dry matter of the chopped forage before and after drying on the mow finishers is shown in Table 2. Except for carotene, there was little difference in the composition of the dry matter of the two lots when they were placed on the drier. The percentage changes in composition of the dry matter due to barn drying are not very large except in the case of the carotene. The significance of these differences in composition are apparent, however, when correlated with dry matter losses to show nutrient losses on a quantitative basis.

The losses of dry matter and feed nutrients, in pounds per ton of dry matter stored and in per cent, are shown in Table 3. Dry matter losses amounted to 9.9 per cent in the high-moisture lot as compared to 5.7 per cent in the low-moisture lot. Thus, for each ton of dry matter placed on the drier, 84.7 lb less dry matter were lost in the low-moisture forage than in the high-moisture forage. This is equivalent to 43 per cent less loss of dry matter for the low-moisture lot (Fig. 3). Likewise, during barn drying protein losses per ton of dry matter amounted to 41.3 lb for the high-moisture lot as compared to 21.1 lb for the low-moisture lot. This amounted to a 49 per cent lower loss for the low-moisture lot. The loss of sugar was 24.3 lb for the high-moisture lot and 11.8 lb for the low-moisture lot. This amounts to 51 per cent lower loss for the low-moisture lot. The loss of the total nitrogen free extract was 93.3 lb for the high-moisture lot and 30.8 lb for the low-moisture. This is equivalent to 67 per cent lower loss for the low-moisture lot.

Differences in field losses of dry matter, due to drying from 39.2 per cent moisture to 32.9 per cent, were not determined but, except for carotene, appeared to be small.

Both forages lost a greater per cent of the carotene than of any other feed nutrient. The high-moisture forage contained more carotene when stored due to exposure for a shorter period in the sun, but lost 27 per cent more carotene during barn drying than the low-moisture forage, and was lower in carotene when barn drying was completed. The carotene content of the hays when barn drying was completed was 41 and 47 micrograms per gram of dry matter, respectively, for the high-moisture lot and the low-moisture lot. These carotene determinations of the dried hays were made from samples taken approximately 8 weeks after the forage had been barn-dried. A small part of the carotene loss no doubt occurred during storage after drying was completed.

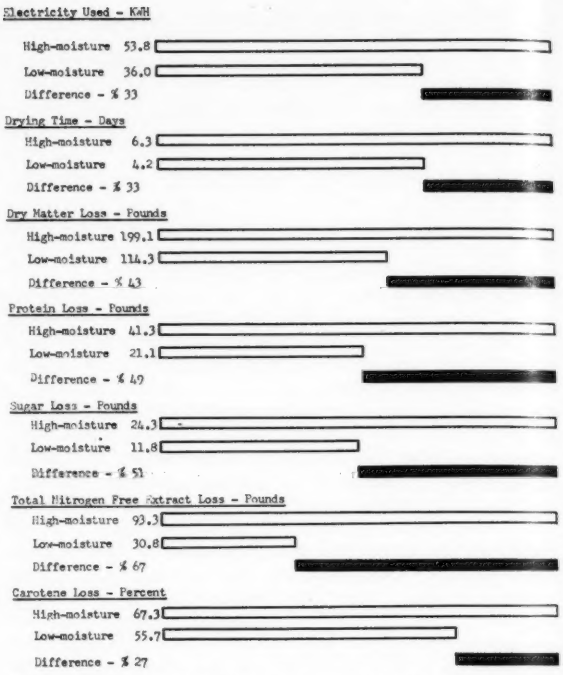

Fig. 3 Comparison of drying time, electricity used, dry matter and nutrient losses from forage of different moisture contents dried on mow hay finishers (per ton of dry matter)

The dried hays, as indicated in Table 4, were both high in quality with a bright green color and good aroma. There were no evidences of mold dust or mustiness except for one small area near the top in the high-moisture lot. Both lots graded U. S. No. 1 mixed hay. The high-moisture lot had 64 per cent green color and contained 53 per cent alfalfa, 20 per cent clover, 28 per cent grass and 3 per cent foreign material. The low-moisture lot had 65 per cent green color and contained 54 per cent alfalfa, 18 per cent clover, 23 per cent grass, and 5 per cent foreign material (Table 4).

TABLE 4. COLOR AND OFFICIAL GRADE OF FORAGE AFTER DRYING ON MOW HAY FINISHERS

Comparison	High-moisture lot	Low-moisture lot
U. S. Grade	U. S. No. 1 mixed hay	U. S. No.1 mixed hay
Color	64 per cent green	65 per cent green
Composition	53 per cent alfalfa 20 per cent clover 28 per cent grass 3 per cent foreign material	54 per cent alfalfa 18 per cent clover 23 per cent grass 5 per cent foreign material

TABLE 3. LOSSES IN DRY MATTER AND NUTRIENTS FROM TWO LOTS OF FORAGE OF DIFFERENT MOISTURE CONTENTS WHEN DRIED ON MOW HAY FINISHERS

Lot	Dry matter	Protein	Fiber	Ether extract	Nitrogen free extract Sugar	Nitrogen free extract Total	Ash	Carotene
Loss of dry matter and nutrients per ton, lb								
High-moisture forage	199.0	41.3	54.6	1.2	24.3	93.3	8.6	
Low-moisture forage	114.3	21.1	55.4	3.3	11.8	30.8	3.7	
Per cent loss of dry matter and nutrients								
High-moisture forage	9.9	11.1	9.8	3.3	22.4	10.3	6.4	67.3
Low-moisture forage	5.7	5.7	9.6	9.5	11.0	3.5	2.9	55.7

SUMMARY

When partially field-cured forage was chopped and drying completed on mow hay finishers, drying requirements and drying losses were higher for forage with a high-moisture content than for forage with a low-moisture content.

(Continued on page 201)

Soil Erosion Studies—Part II

Soil Detachment Hazard by Raindrop Splash

By W. D. Ellison
MEMBER A.S.A.E.

THE approach to this study of soil erosion problems was discussed in the preceding paper[1]. In that discussion the soil erosion process was divided into the two parts of (1) soil detachment and (2) transportation. When a study of the erosion on a particular field is directed along these lines the results will reveal a detachment hazard and transportation hazard for that field. These separate evaluations of the soil erosion hazards will help to show whether the major corrective measures should be designed to correct soil detachment or soil transportation.

Also, in the preceding paper it was stated that falling raindrops and flowing surface water would have to be treated as separate agents, and that the soil erosion caused by each would have to be studied separately. Raindrops and surface flow act as independent variables, and while the principal effect of raindrops is to detach soil, the principal effect of surface flow (outside the gullies) is to transport the detached soil materials.

When falling raindrops strike the ground surface or the thin films of water covering it, they splash small bits of soil into the air (Fig. 1). These splashed particles reach varying heights, ranging up to more than two feet, and they may move horizontally more than five feet on level surfaces[2]. More than 100 tons per acre may be splashed by the most beating types of rains, on bare soil which is highly detachable.

In our study of the detachment hazard which results from these splashes, we are not particularly interested in the distance or the direction of their travel. Rather we are interested in how many pounds or tons of soil are splashed. Splashed material represents detached material, and thus we may use a measure of soil splash to represent the detachment caused by the impact of falling raindrops. While the splash does not represent an exact measure of the soil detachment, methods can be used for measuring the splash which will make the difference between this measure and the detachment very small.

The quantity of soil detached will be proportional to the *detaching capacity* of the falling raindrops and the *detachability* of the soil. If the detachment hazard is designated as D_1, its magnitude can be determined by the equation

$$D_1 = D_2 \times D_3 \qquad [1]$$

Where D_1 = the soil detachment hazard
D_2 = the soil's detachability. (It is equal to the number of units of soil detached by each unit of detaching capacity of the erosive agent)
D_3 = the capacity of the erosive agent to detach soil. (It is equal to the total units of detaching capacity contained in the erosive agent.)

To compute D_1, the factors of D_3 and D_2 must first be evaluated. They will be discussed in that order.

Detaching Capacity of Falling Raindrops (D_3). In order to determine the magnitude of the detaching capacity of falling raindrops, they are made to splash on a standard "soil" of unit detachability, on which the detachability remains constant. A standard fine sand is used as the standard soil. This standard sand is a fine round-grained material, all of which passes through a 60-mesh and is retained on a 70-mesh sieve. It is washed clean so that it contains no binder materials. It will splash at a constant rate so long as there is no change in the characteristics of rainfall, but a change in either drop velocity, drop size, or rainfall intensity will bring about a corresponding change in the rate of the sand's splash. In some experimental work the author[2] found that the soil splash on a Muskingum silt loam varied as the drop velocity, $V^{4.33}$; the drop diameter, $d^{1.07}$; and the rainfall intensity, $I^{0.65}$. These relationships have not yet been tested for the standard sand. We do know, however, that a change in any one of these three characteristics of the rainfall will bring about a change in the splash of the sand.

In our experimental work the standard sand is placed in a small aluminum soil cup of 3.5 in diameter and about 2 in deep (Fig. 2). Holes of 0.25-in diameter are bored in the bottom of the cup, and approximately 0.5 in of cotton is spread in the bottom to keep the sand from flowing through these holes. The cup is then filled with oven-dried sand and weighed. After weighing it is thoroughly saturated, and it is then ready to set on the coiled asbestos wick on top of the jar where it will be kept completely saturated so long as water is kept in the jar. Saturation is to prevent the sand from blowing out of the cup.

During rainfall the sand will be splashed out of the cup. After the rain is over, the cup is removed from the jar and the sand is again oven-dried and weighed. Care must be taken in the drying process not to use a hot oven which will burn the cotton. The difference

Fig. 1 The several vertical, longer white lines are paths of falling raindrops and the hundreds of other dots and lines at various angles are paths of splashes containing soil particles. No land is level enough to escape this

This paper was prepared expressly for AGRICULTURAL ENGINEERING, and is the second of a series to appear in coming issues.

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[1] Soil Erosion Studies - Part I, AGRICULTURAL ENGINEERING, April, 1947, vol. 28, no. 4, pp. 145-146.

[2] Studies of Raindrop Erosion, AGRICULTURAL ENGINEERING, April, 1944, vol. 25, no. 4, pp. 131-136, and May, 1944, vol. 25, no 5, pp. 181-182.

in the dry weight of the cup of sand before and after rainfall is used to represent the total detaching capacity of the falling raindrops (the D_3 factor in equation [1]), and it is expressed in grams.

The rates of splash which leave the cup will decrease as the sand in the cup is lowered and the sides of the cup interfere with the sand splashes moving out. A calibration curve is needed to show this decrease in the rates of sand splash before these data can be accepted as accurate.

Detachability of a Soil (D_2). When we measure soil detachability under raindrop impacts, we find two principal groups of factors affecting the results we obtain. The first group is comprised of those things which affect the soil's consolidation under the impact of raindrops. If the soil consolidates through compaction and cementation of the separate particles under the impact of raindrops, this will cause a decrease in the rates of soil detachment. The second group of factors which affect the measured results includes the stone fractions, firm clods, and other materials which resist being broken down to highly transportable sizes. If the soil contains considerable amounts of these, then just as soon as some of the fines are splashed away and the coarse materials begin to appear in excess on the surface, the rates of soil detachment will decrease.

Because of great differences in these two groups of factors, it will be important that we study them separately. To do this we must make two types of tests in evaluating the detachability factor. The first test will be made with a screened soil from which all stones and firm clods of low transportability have been removed, and the second test will be made on field conditions of these same soils, from which the stones and clods have not been removed.

In preparing the soil for the first test, it is screened (in air-dried condition) through 2-mm openings. (Fractions of 2 mm were previously found to be highly transportable by the splash process[2].) This screened material is next poured into a soil cup as shown in Fig. 2 and weighed. After weighing it is set on a moist pad and permitted to take up water slowly through the cotton in the bottom of the cup until it has become completely saturated. It is then ready to be exposed to rainfall, and in doing this it is handled in the same way as the sand cup for determining the amount of soil that is splashed out. Soils which tend to consolidate under the action of rainfall will splash less than do soils which do not consolidate.

To determine the soil's detachability, the soil and the sand cups are exposed simultaneously to rainfall. The amount of *soil* splashed from a cup is then divided by the amount of standard *sand* splashed out of a similar cup. For example, if 50g (grams) of a particular soil is splashed out of the cup, while 100g of standard sand is splashed out of an adjacent and similar cup, the detachability of that soil will be 50/100, or 0.50. This will be the value of D_2 which reflects the consolidating properties of the soil and which in turn affects the detachment process. This value may be used in furthering studies of the effects of different chemical and biological properties on soil detachment. It will be free of the influences of stones and firm field clods and it will express quantitatively the effects of those things in the soil which tend to bind and hold the particles together.

A small rainfall applicator as shown in Fig. 3 is handy for this work. It consists of a type-F nozzle, from one of the standard rain makers, which is supplied with water from a laboratory spigot. This sprays water over the screen consisting of chicken wire covered with cheesecloth, and with a yarn string in each depression. This screen is 18 in square, and a funnel collects waste water on all sides of the screen and returns it to the sink. The samples are placed on the rotating

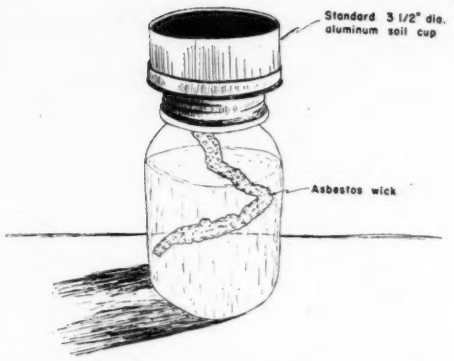

Fig. 2 A splash dish for measuring the capacities of storms (D_3) and also used in laboratory work for measuring the detachability of a soil (D_2)

table, each equal distance from the center point to make certain they rotate in a common path and each receive identical rainfall treatment.

The second test will be made on field soils from which the stones and clods have not been removed. This can be made by using two small trough-shaped frames approximately 18 in square, as shown in Fig. 4. Inside of frame a will be the undisturbed field soil, and inside of frame b the natural field soil is covered with 0.5 in of the standard sand. Splash boards 24 in high are set on these frames so they will intercept the material that is splashed[3].

In fields where the surface is very irregular, it may be desirable to use a frame larger than 18 in square. In expanding these frames, it will be desirable to limit widths to 18 in, and increase only one dimension. Frames of 18 x 24 in, 18 x 30 in, or 18 x 36 in may be desirable in some instances.

It is necessary that we obtain maximum values of D_2 in order that our tests and computations to determine the detachment hazards will represent maximum conditions. However, in addition to determining maximum values of D_2, a wide range of field conditions should be tested to find how much effect variations in the different field conditions will have on soil detachment. For example, we should determine

[3]Usually less than one per cent of the splashed material reaches a height of more than 2 ft.

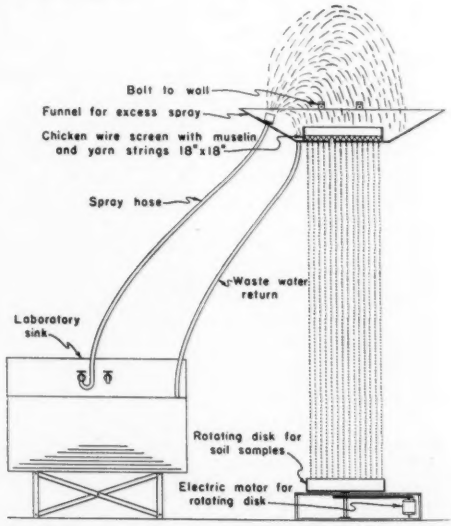
Bolt to wall
Funnel for excess spray
Chicken wire screen with muselin and yarn strings 18"x18"
Spray hose
Waste water return
Laboratory sink
Rotating disk for soil samples
Electric motor for rotating disk

Fig. 3 A convenient rainfall applicator for the laboratory for testing D_2 factors of screened soil

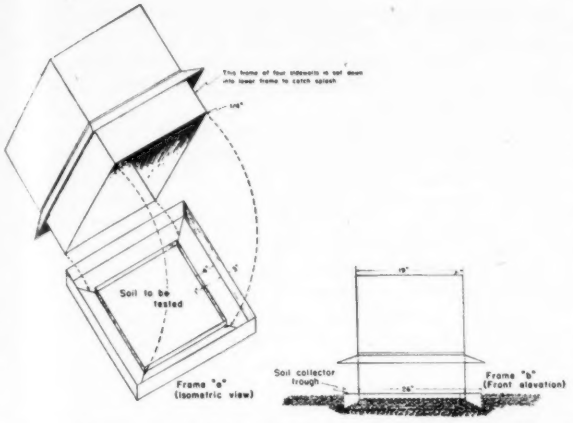

Fig. 4 Frames used in field sampling to determine the D_2 values of various field conditions and in establishing the R values for various crop covers and mulches

how variations in amounts of lime and chemical fertilizers applied and variations in amounts of organic matter will affect the D_2 factor, and how much the effects of different methods of tillage and other variations in soil conditions will cause the D_2 factor to vary. The broader our understanding of the effects of different field conditions on the D_2 factor, the more able we shall be to determine how to obtain best results in field management.

In making these tests it will be necessary to have the raindrops fall vertically so that the splash boards will not interfere with their fall. These difficulties will make it desirable to use artificial rain to avoid waiting an indefinite period for a high impact storm in which the drops fall vertically. For this work an inexpensive rainfall applicator can be rigged up as shown in Fig. 5. This same apparatus can be used in testing the values of D_2 for the screened soil.

Following rainfall, the soil splash in frame a (Fig. 4) is collected, dried, and weighed, as is the splashed sand in the adjacent frame b. The amount of splashed soil is then divided by the amount of splashed sand and the dividend represents the D_2 value for the open field.

After we determine the value of D_2 applying to open-field

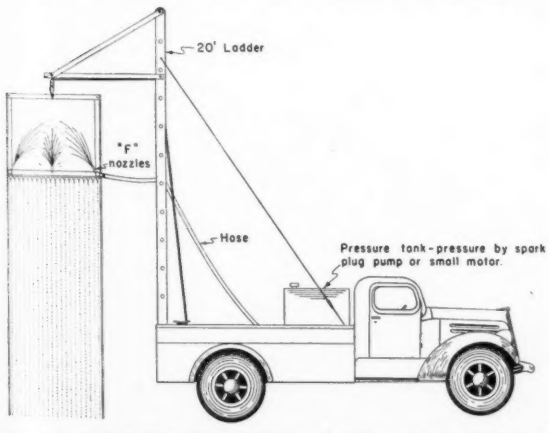

Fig. 5 A rainfall applicator for testing different soils and covers under field conditions. A canvas cover protects water drops from wind. Best results are obtained when F nozzles are on a 5x5-ft frame suspended 4.5 ft below top of canvas, and a 4x4-ft screen with yarn to form drops is suspended about 4 ft below nozzles. A handline is used to vibrate screen where drops are formed and "mix" raindrop pattern. In wind, the extension ladder must be supported by guy ropes from top of apparatus

conditions, we may substitute this in equation [1], and for the D_3 values we use the amount of sand splashed from the small sand cup shown in Fig. 2. If we multiply the D_1 obtained from equation [1] by ¾, the result will express the detachment hazard in tons of soil splash per acre.

Fig. 6 shows detachability curves for a soil. The upper solid line is for the screened soil, and the lower broken line is for the same soil in field condition. If the rainfall should cease at either point "a" or point "b" on the D_3 axis, the detachability of the soil may increase as shown by the broken lines, as the soil dries. Some soils will undergo considerable change upon drying, while others will change very little.

There are a number of ways in which the soil detachment hazard can be evaluated and used. It can be evaluated for a single storm, for a short season, for an entire year, or for a rotation system covering several years. In order to estimate the effects of different soil characteristics on the total amounts of soil detached by raindrop splash from a bare surface during an entire season, it would be necessary to know (1) the detachability curve of the soil, (2) the change which takes place in that curve when the soil dries, and (3) the number of times the soil will be cultivated, as each cultivation will raise the detachability curve to its level at the zero point of the D_3 axis.

The total storms during a season will have a bearing on the magnitude of the detachment hazard that can be tolerated for each storm. For example, if the detachment hazard is high for each storm, but only a few storms occur during the season, then the total for the season may remain low and a fairly high storm detachment hazard may be tolerated. If on the other hand there are many storms, the hazard for a single storm may have to be maintained at a low level to avoid a high total detachment. Some practical experience will be needed before one can determine the magnitude of the D_1 factor which may be tolerated on each field. This will be different for each soil, each slope, and each change in frequencies of storms.

Values of R (Crop and Mulch Covers). The value of D_3 represents the effective energy of the falling raindrops that is applied on the surface of the land where the ground is bare and there are no crop or mulch impediments. Under these conditions we determine the erosion hazard by the equation [1]. However, when growing crops or mulches impede the velocities of the falling raindrops, we may think of these impediments as representing a resistance factor which we will refer to as R.

The R values indicate the effectiveness of vegetation or mulch in checking falling raindrops. We must determine the R values for different soil covers and for different conditions of each cover in order to know how effective each will be in reducing the soil detachment hazard. In this work we rewrite equation [1] to read:

$$D_1 = \frac{D_2 \times D_3}{R} \qquad [2]$$

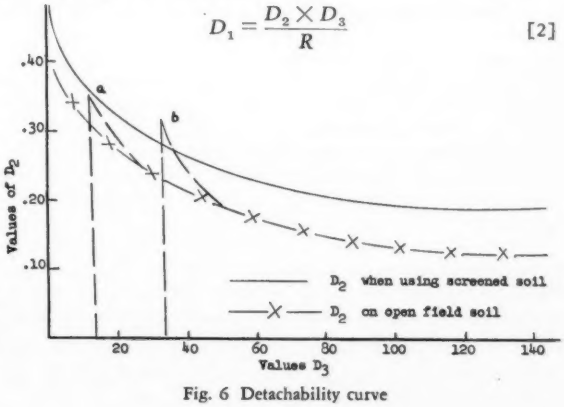

Fig. 6 Detachability curve

Fig. 7 To get this picture, the camera was located in a dry pond after a heavy rain. Note organic matter and clay washed out of the field and into the pond, even on very gentle slopes. White material between rows is sterile sand out of which this clay and organic matter was washed. (Courtesy Seabrook Farms, Bridgeton, N. J.) Fig. 1 shows how the washing process took place

Where R = an impact-conditioning factor[4]. This value will be proportional to the effects of the cover in impeding falling raindrops. It will vary from one cover to another, as well as for different conditions of each cover.

To obtain R we use the two frames a and b shown in Fig. 4. In frame a all of the mulch and vegetative cover are removed and the soil inside the frame is then covered with 0.5 in of standard sand. In frame b the soil is also covered with 0.5 in of standard sand, but the cover is left standing. If mulch and residue materials are beneath the canopy, a like amount of these must be spread on top of the sand to simulate the surface protection found under the vegetation before the sand was spread. After this has been done, the two plots will be ready for application of rain, and following rainfall the sand splashed in each of the frames is collected separately, dried, and weighed. To obtain the R value of the vegetal cover, the sand splashed inside the frame which has no vegetation is divided by the sand splashed in the frame which retained its vegetation. If we measure 500 g of sand splashed in frame a (Fig. 4) where there is no vegetative cover and only 50 g in frame b where the vegetative cover is left standing, the value of R for this cover is then $500 \div 50 = 10$. In other words, this cover reduces our detachment hazard D_1 to one-tenth of what it would be without such cover. This R is the factor we manipulate in land use, to make the detachment hazard which is caused by raindrop splash approach zero.

Where the vegetation seems to interfere greatly with the lateral movement of the splashes, it will be necessary to narrow down one dimension of the frames shown in Fig. 4. The greater this interference by leaves and stems of plants, the narrower the plots should be. The narrowest plots so far tested were 4 in wide and 2 ft long. Where the vegetation is dense and tall, the values of R obtained by this method will decrease with each decrease in plot width, until a narrow width is reached which does not permit the vegetation to interfere greatly with the splashes. After this narrow width has been reached, further decreases in plot widths will not make appreciable change in R values.

There is a need for determining the R values of different types and densities of vegetation. These studies must also evaluate changes which occur from month to month and, in some cases, even from week to week throughout the year. Each different crop will have a characteristic R curve for the year.

[4]The author is indebted to Dr. B. T. Shaw and Dr. R. M. Salter for assistance in establishing the use of R.

We can change these curves by changing to either earlier or later plantings, by changing the planting patterns, by changing the quality of cover, and by other means. We need to know how to manipulate the R values and how much we can manipulate them.

We can also increase R values on a field by using mulch. We must learn the R values of different mulches. We also need to know the effects of a canopy and mulch acting together. After we have determined the R values applying to different canopies and mulches throughout the entire year, we will then be able to design cover practices which will effectively reduce the detachment hazard under raindrop action and maintain it at some predetermined low level[5].

In areas where the detaching capacity of the rainfall varies from season to season, the R values may also be permitted to vary. Let us use the problem shown in Table 1 to emphasize this point. Here the detachability (D_2) equals 0.50, and it is constant for the year. The D_3 values vary throughout the year, as shown in the tabulation that follows. If we have determined that we can tolerate only a detachment hazard of 5, then the R values required to make necessary reductions in the detachment hazard for each of the seasons listed will be as indicated in the bottom column of the tabulation in Table 1.

TABLE 1

Factors affecting soil detachment	Dec Jan Feb	Mar Apr May	Jun Jul Aug	Sep Oct Nov
D_2	.50	.50	.50	.50
D_3	20	60	100	40
$D_1 = D_2 \times D_3$	10	30	50	20
R values required to reduce D_1 to 5 (Equation [2])	2	6	10	4

Where the R values of crop canopies are inadequate to reduce D_1 the required amount, and during periods of seedbed preparation when bare soil is exposed, the required increases in values of R may be achieved with mulches. Large amounts of mulch have been found to depress some yields. Therefore, it is essential to know the amounts of mulch needed to reduce

[5]Computations for determining the required R: If $D_2 = 0.50$ and $D_3 = 100$, the required R to make $D_1 = 5$ is determined by the equation $D_1 = (D_2 \times D_3)/R$, or $5 = (0.50 \times 100)/R$, or $5R = 50$, $R = 10$.

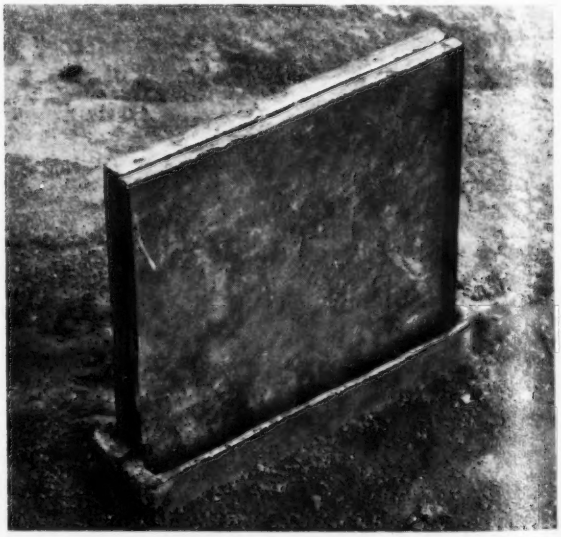

Fig. 8 A splash sampler. Splashes as shown in Fig. 1 strike the vertical plate and fall or flow down into trays at the base of the plate

the detachment hazard, so that inadequate mulch covers will not be relied upon, and that unnecessarily large amounts of mulch may not be used at the expense of crop yields.

The values of R for some vegetations will vary in their magnitude with changes in the characteristics of rainfall. Vegetations which contain very flexible stems and leaves and which grow close to the ground may be highly effective in checking the impact of raindrops when a storm is made up of small drops falling at low velocities. These same vegetations may fail to dissipate significant amounts of raindrop energy in storms made up of large drops which fall at high velocities. Such results were obtained in some exploratory work on a field of young clover where there was a dense stand which completely covered the soil. In this field all of the small drops which fell at low velocities were completely checked, but the large drops which fell at high velocities were hardly affected.

It would seem desirable eventually to establish the relationships of changes in R to changes in rainfall characteristics. However, a first step should be to determine values of R for large drops falling at high velocities. This must be done in order to determine the minimum values of R by a standard of heavy rainfall. If it develops later that some of these vegetations are to be used in areas with rains of either greater or lesser impact, additional tests may then be made to determine the working values of R applying to these vegetations in the new locations. The following standards of rainfall characteristics are suggested for testing values of D_2 and R; drop size, 5 mm; drop fall, 14 ft; intensity, 6 in per hr.

SPLASH MEANS SEVERAL TYPES OF HAZARDS

Some Problems in Application. Soil detached by the splash process may represent several types of hazards. When once detached it is readily available for transport, and in this state it represents an erosion hazard, whether or not it is carried off a field. A second hazard is that of elutriation, or the washing out of the more valuable parts of the soil and leaving the stone and sand fractions on the field. Through elutriation, humus and many other nutrients as well as clay and other light fractions of the soil can be lost from the field. Seed may also be separated out and floated away. On gently sloping areas and on soils which are high in sand content this elutriation process may rob the soil of much of its fertility without any considerable tonnage losses. Fig. 7 shows a field near Bridgeton, N. J., with this type of soil damage. The white material between the bean rows is heavy sand out of which has been washed the organic matter, the clay, and other light and transportable materials. Here the raindrops served somewhat the same function as the agitator in a washing machine. They splashed the soil, broke down clods and crumbs, and caused many of the aggregates to release their humus and other light materials, and they kept this light material in suspension by successive splashes which kept the water highly agitated.

Soil decline may result from either high tonnage loss of soil materials from a field, or from elutriation which washes out the soil's organic matter and other nutrient materials. In either case the rate of decline is certain to be a function of the detachment hazard in the splash process. In a later paper another aspect of the detachment hazard will be discussed. This will relate to muddying the surface water by splash, which in turn impedes infiltration and increases the runoff. This increased runoff will aggravate many phases of the soil erosion, water conservation, and flood problems.

A rough estimate of the amount of splash which occurs on each field can be obtained by using a splash board such as shown in Fig. 8. This splash board has a small compartment at the bottom of the vertical plate for collecting a sample of the splash. It was discussed in more detail in a previous article[6]. These have been used in exploratory work in research studies and it would also seem advisable to use them in many crops and in many fields to gain some idea of the magnitude of the splash erosion problems.

On old pastures covered by a poor stand of grass, the splash is often very active. When seed or fertilizers are spread on such a surface the splash may set these materials in motion in the surface flow. When this happens, the losses of seed and fertilizers may run very high.

An outstanding advantage of the methods outlined in this paper for studying soil detachment by raindrops is that storms, soils, and vegetal covers are each evaluated in terms of a common base—a standard sand. That is, storms are compared one with another on the basis of how much of the standard sand they will splash. Soils are compared one with another on the basis of how their detachability compares with that of the standard sand. And vegetal covers are compared one with another on the basis of how much they will reduce the amount of standard sand splashed when the raindrops pass through the vegetal covers before striking the sand.

We are in immediate need of information concerning the effects of all types of soil covers on soil detachment by falling raindrops. Some of our pasture and range lands now being grazed too short and damaged by erosion could undoubtedly be conserved with a very little less grazing. But once the splash becomes active, enough damage may be done in a few storms to make re-establishment of a full cover a long and expensive process. On many old timothy meadows, after the clover is gone, there is severe splash erosion each time the grass is cut close to the ground.

On our crop lands the R values of companion crops as well as those of single crops, and the R values of crops with various mulch covers must be established for each period of the year. That is, they must be before these methods can be used effectively for designing soil conservation programs which provide for controlling the soil detachment hazard set up by raindrop splashes.

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[6]Two Devices for Measuring Soil Erosion, AGRICULTURAL ENGINEERING, February, 1944, vol. 25, no. 2, p. 53.

Effect of Moisture Content on Drying Requirements and Nutrient Losses

(Continued from page 196)

Field drying to the lower moisture content reduced drying time on the mow hay finisher and the electricity used in drying by 33 per cent. Losses due to barn drying were also reduced by the following: dry matter, 43 per cent; protein, 49 per cent; sugar, 51 per cent; total nitrogen free extract, 67 per cent, and carotene, 27 per cent. Due to these smaller losses 4.7 per cent more barn-dried chopped hay was available for feeding from the low-moisture lot than from the high-moisture lot.

The high-moisture forage contained the most carotene at the time of storage but was lowest in carotene after barn drying was completed.

Both lots of barn-dried hay were graded U. S. No. 1 mixed hay and were similar in composition except for carotene.

REFERENCES

1 Woodward, T. E. and Shepherd, J. B. An Experiment in Chopping Alfalfa Hay at the Time of Storage. Journal of Dairy Science, vol. 19 (1936), no. 11, p. 697.

2 Shepherd, J. B. and Woodward, T. E. Further Investigations in Chopping Alfalfa Hay at Time of Storage. Journal of Dairy Science, vol. 21 (1938), no. 2, p. 89.

3 Duffee, F. W. The Chopping and Storing of Hay. AGRICULTURAL ENGINEERING, vol. 23 (June 1942), no. 6, p. 195.

4 Chopped Hay Studies. Ohio Agr. Expt. Sta. Annual Report (1933), Bul. 532, p. 89.

Flow of Air through Chopped Hay in Mow Driers

By H. D. Bruhn
MEMBER A.S.A.E.

BECAUSE of the reduction in the amount of labor required, Wisconsin farmers in increasing numbers are employing the field chopping method of hay harvesting and storage. They are making this change at the risk, on one hand, of considerable leaf loss if the hay is too dry when chopped, and, on the other, of mow sweating with dangers of mold spoilage or spontaneous ignition if the hay is too wet. In view of this trend, the major part of the barn hay-curing research work at the Wisconsin Experiment Station has been with chopped hay.

This paper was presented at the 3rd Barn Hay-Curing Conference sponsored by the American Society of Agricultural Engineers, at Chicago, Ill., December, 1946.

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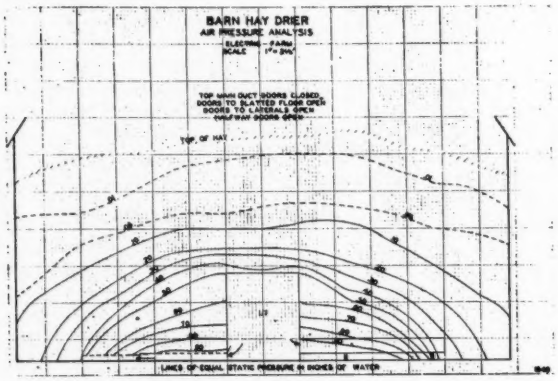
AUTHOR'S NOTE: The author desires to give special credit for the assistance rendered by the following senior students of the University of Wisconsin who helped in the accumulation and compilation of data presented in this paper: Russell Kilpatrick, Robert Witt, William Johnson, Charles Owens, Neil Summers, Harold McKnight, and Donald Jewell.

Where the barn-feeding season is relatively long, as it is in Wisconsin, dairy cattle require large quantities of good roughage, and barns are, in general, quite large and high. The early barn hay driers proved entirely inadequate for chopped hay in these barns because, in the way in which it was being chopped, it offered so much resistance to the flow of air out of the ducts and through the hay that sufficient air to properly dry the hay was not being forced through it.

A long cut with little beating of the hay will do much to reduce the pressure required to force air through hay of such depth. However, to date the manufacturers of field choppers have not given us cutters that would give a theoretical length of cut over 2½ in, and with many cutters any approach to this length results in leaf separation and shattering through rubbing and knocking of the hay by various structural members of the cutting mechanism before the cutting knife itself reaches the hay.

Conventional Mow Air-Flow Analysis. The early difficulties with driers were responsible for the development of the



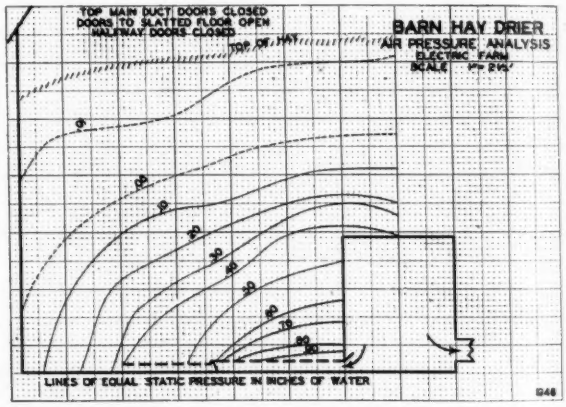
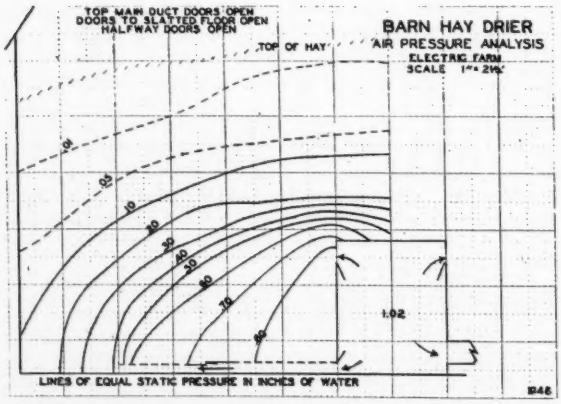

TOP MAIN DUCT DOORS CLOSED
DOORS TO SLATTED FLOOR OPEN
HALFWAY DOORS CLOSED
BARN HAY DRIER
AIR PRESSURE ANALYSIS
ELECTRIC FARM
TOP OF HAY
LINES OF EQUAL STATIC PRESSURE IN INCHES OF WATER

Fig. 1 *(Left)* Cross section of barn hay drier showing lines of equal static pressure in a barn 34 ft wide with a central main duct 4 ft wide and 6 ft high and with approximately 15 ft of chopped hay on the system. The slatted floor is on the left side, and the lateral ducts with partially closed bottoms raised 6 in above the floor, on the right side. The form of the isobars indicates that there is very little difference in the performance of the two different types of distribution systems • Fig. 2 *(Right)* When the doors under the slatted floor were closed to shut off air flow to the outer half of the area, a reduction in pressure out near the barn wall was brought about with a resultant decrease in air losses to the side of the barn



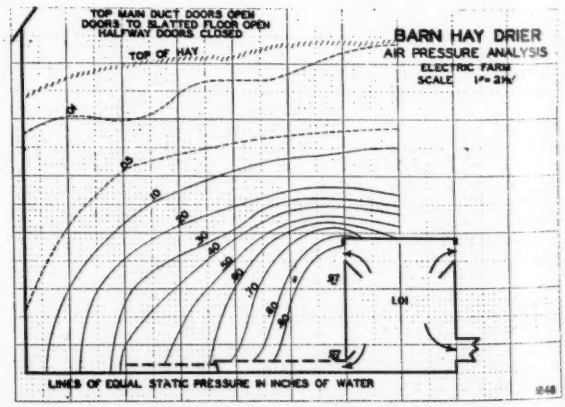


Fig. 3 *(Left)* By opening horizontal doors near the top of the main duct, air could be released at this point to facilitate drying a greater depth of hay • Fig. 4 *(Right)* Opening the horizontal doors at the top of the main duct and closing the air supply to the outer half of the slatted floor reduced air leakage at the outer wall. This is shown by the fact that the pressure is less near the outer wall

lateral duct with the partially closed bottom raised 4 to 6 in above the floor. Conventional open-bottom lateral ducts raised 4 in above the floor were also used.

While these developments were all improvements, they failed to solve the problem of getting the air through a layer of chopped hay 16 to 20 ft deep without exceptionally high pressure and serious air losses through the side of the barn. To relieve these conditions to some degree the high, narrow, central main duct with narrow doors near the top was developed. Furthermore, it was thought that a slatted floor would be as effective as the lateral ducts. A system in which it would be possible to check these details was constructed in a mow 34 by 56 ft. The system had a central main duct 5 ft wide and 6 ft high. On one side of the main duct, 10 ft long, lateral ducts were installed with a 2-in bottom opening 6 in above the floor. The lateral duct spacing was 4 ft center to center.

On the opposite side of the main duct a slatted floor was installed. The slatted floor was supported by 2x6-in stringers set on edge and extending 6 ft out from the main duct. The next 4 ft out two-by-fours were used to support the slatted floor. At the offset doors were installed. The outer 2 ft of the high portion of the slatted floor was covered with roofing paper to block the air flow around and above the doors when they were closed.

With available instruments it is only possible indirectly to determine the air velocity and direction in a mass of hay. The instruments used for this work were the common probe and the Ellison draft gauge. From this data the isobars (lines of equal static pressure) of Figs. 1, 2, 3, 4, and 5 were obtained. The direction of the airflow, of course, is essentially normal to the isobars since air flows from a higher pressure area to an area of lower pressure. Closely spaced isobars indicate either (or both) high air velocity or dense masses of hay. A condition which produces a higher pressure near an outside wall indicates greater loss of air to the outside as long as the outside wall remains the same.

The shape and location of the isobars in Fig. 1 show no important variation on the two sides of the drier. Furthermore, with the fan operating at the same speed, if the distribution system on either side were shut off, the static pressures

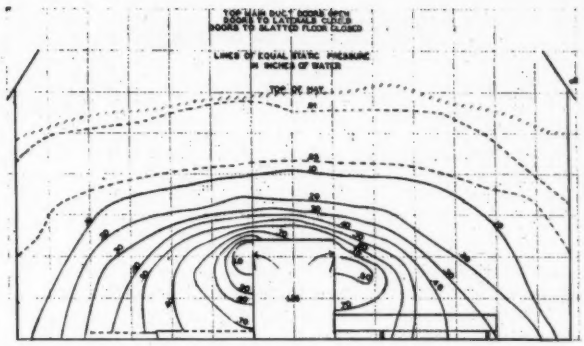
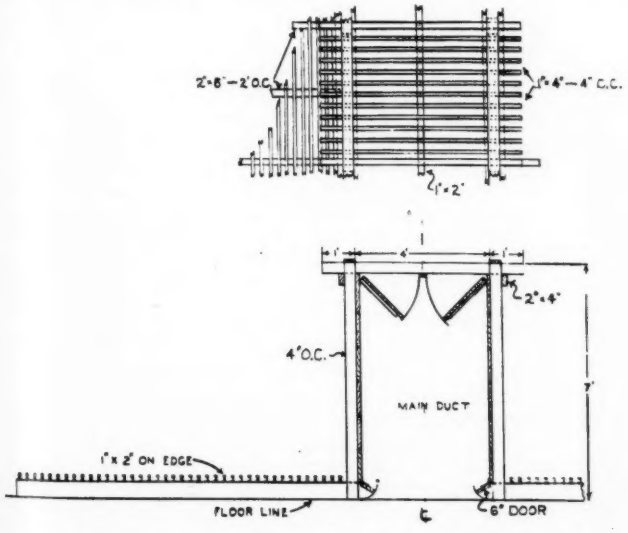


Fig. 5 Further reduction of air losses to the outer wall can be brought about by closing off all air supply at the floor level and allowing all air to escape through the horizontal doors near the top of the main duct. At the same time, good air distribution is obtained in the upper area of the mass of hay. The fact that the outlet doors are too small and the air velocity entering the hay is too high is shown by the higher static pressure in the main duct

developed in the main duct were approximately equal. Therefore, from an air distribution standpoint the slatted floor was considered equal to the lateral duct system.

The doors under the slatted floor, commonly referred to as halfway doors and shown closed in Fig. 2, reduced considerably losses to the side of the barn. There was approximately 0.1 in less air pressure near the base of the outside wall when the halfway doors were closed.

With the halfway doors open and in addition the top main duct doors open, as shown in Fig. 3, the floor and outer wall conditions again were very similar to the conditions of Fig. 1. However, the pressures above the main duct in Fig. 3 were considerably higher than in Fig. 1 which indicated that opening these top main duct doors brought about a major increase in the air going up through the central portion of the mow. Furthermore, a sizable reduction in main duct pressure was accomplished. By closing the halfway doors and leaving the top main duct doors open, as shown in Fig. 4, the outer wall condition was again improved.



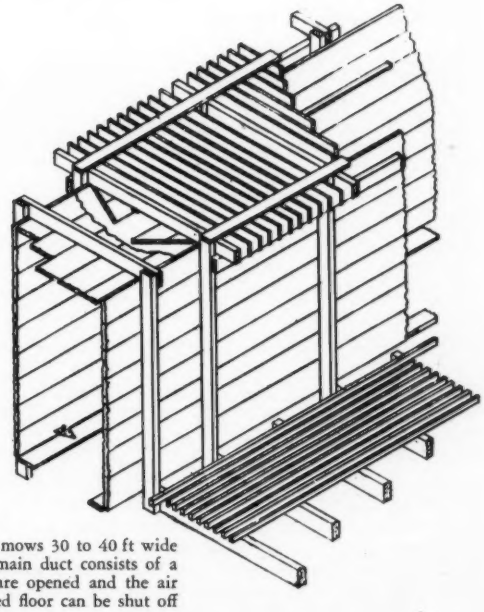


Fig. 6 *(Above)* A main duct and slatted floor design to facilitate barn hay curing in mows 30 to 40 ft wide containing masses of hay up to 16 or 18 ft deep • Fig. 7 *(Right)* The top of the main duct consists of a grill with doors below. When 5 or 6 ft of hay cover the main duct, these doors are opened and the air is allowed to enter the hay through a considerable area. The air supply to the slatted floor can be shut off as soon as the hay in the lower portion of the mow is dry

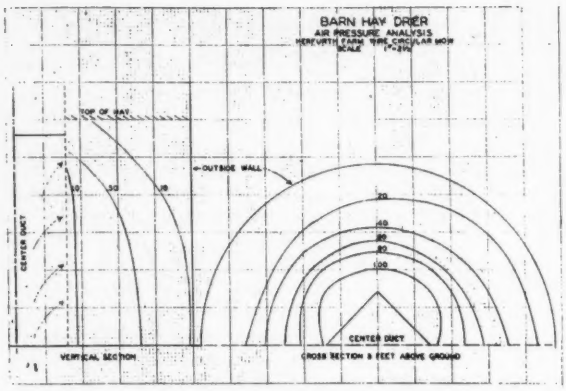


Fig. 8 The circular hay-drying unit shows some promise if doors are provided in the central duct to control the air. The velocities of the air at the entrance to the hay must be rather high

The next step, then, was closing off all air flow to the floor portion and allowing all the air to enter the hay from the top main duct doors as shown in Fig. 5. This gave a very slight further improvement in the outer wall condition, and a further increase in air through the center of the mow. A serious objection to this arrangement, however, was that the top main duct doors with a 9-in opening were not large enough and there was not enough hay surface exposed for air entrance into the hay. This is indicated by the higher main-duct pressure.

A Redesigned Main Duct. To reduce pressure while all the air is being discharged at the top of the main duct, the duct shown in Figs. 6 and 7 was designed. This duct has two doors which make up the major portion of the top. A grill constructed of one-by-fours set on edge, 4 in center to center, supports the hay above the doors. For structural purposes a two-by-four is substituted for the one-by-four at the side posts which are at 4-ft intervals. The top grill extends at least a foot in narrow barns and in wide barns 1½ ft beyond the sides of the main duct. Thus, if a system for a barn 34 ft wide is designed for 10 cfm per sq ft with a 1-ft overhang of the grill, the air flow at the grill will have to be 57 cfm per sq ft, which is too high. Nature, however, improves this slightly because a horizontal fissure usually develops at the end of this grill work which, for all practical purposes, extends the air entrance area 1½ to 2 ft on both sides. When this is taken into consideration, the entrance velocity at the hay surface is about 38 cfm per sq ft of area, which may be satisfactory, although a further reduction would be desirable.

With only the top of the main duct open it is questionable, however, whether it would ever be possible to reduce the static pressure in the main duct to the equivalent of the pressure when the lateral ducts or slatted floor are open, because there is less outside leakage when the top only is open.

While halfway doors under the slatted floor were very effective, it was not considered worth while to continue their use. They would not be used in drying the first six or eight-foot layer. They might be used in drying the second layer, but for the third layer all the floor air would be shut off. Therefore, to simplify construction they were omitted. The outer edge of the slatted floor is left open so it will be self-cleaning. The material suggested for the slatted floor is one-by-twos on edge spaced about 2½ in center to center.

A Circular Metal Container with Radial Air Flow. Observations were also made on a circular-wire enclosed steel frame hay storage unit (Fig. 8). This unit was constructed with a vertical center duct. The air was to pass radially outward. The center duct could be blocked off at any desired height. As shown by the isobars in the horizontal cross section, air distribution was fairly uniform. Fundamentally, of course, the air velocity entering the hay must be much higher than on leaving at the outer edge. In this case the ratio was 3.5 to 1. The isobars in the vertical section show that there is a decided tendency for the air direction to swing up through the less dense hay near the top. In common hay-making practice the last hay brought in is often the driest, and the most air then goes where there is the least moisture to remove. Unless some provision is made to close off the lower portion of the central duct, these units are not practical for drying a second batch unless the dry hay is first removed since there is no way to prevent air loss through the already dry hay.

Velocity and Pressure Relationship. Since it is impossible to determine with any degree of accuracy the exact amount of air passing through the hay in a large conventional barn-drying system, mow-drying experiments have been carried on in a silo for the past two years. In this experiment it was possible to measure the air flow to the hay quite accurately and there was little chance for side leakage. This past season the hay was put in and dried in three layers. The total depth when filling was completed was 19½ ft; however, at the conclusion of the drying there were 16 ft of settled hay. The upper 12 ft were a mixture of alfalfa and timothy chopped and blown into the silo with an ensilage cutter set for 1.75-in cut. The lower 4 ft were a mixture of alfalfa, weeds, and June grass chopped in the field with the machine set for 1½-in cut. A special blower was used to elevate the material into the silo. This mass of hay probably offered slightly higher resistance to the passage of air than a long-cut, straight alfalfa hay; however, any farmer might have this same type of hay, and if he operated his chopper on a shorter length of cut the resistance could easily be higher.

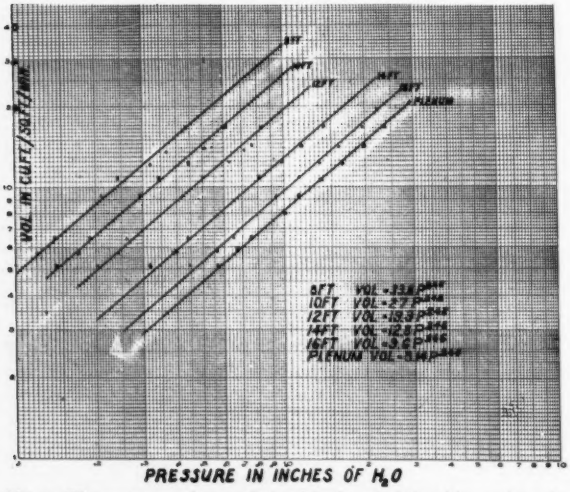


Fig. 9 The pressure-volume relationship for air being blown through various depths of mixed chopped alfalfa, bromegrass, and bluegrass hay. In the exponential equation the exponent remains essentially constant regardless of the depth. The coefficient varies inversely as a function of the depth

The data taken from a series of tests to determine the resistance offered to the flow of air at various rates of flow through the entrance grill and 16 ft of settled hay is shown as plotted on log log paper in Fig. 9. The fact that this data plotted as a straight line on log log paper indicates that the relationship of volume and pressure can be expressed by the equation $V = Cp^n$. The equation calculated analytically from this data is:

$$V = 8.14p^{0.846}$$

V = cubic feet per minute per square foot of mow area

p = static pressure in inches of water.

(Continued on page 207)

Hay Density in Relation to Various Factors

By George E. Zerfoss

MEMBER A.S.A.E.

A KNOWLEDGE of the physical characteristics of hays and their relation to the many factors involved in hay drying is essential to continued progress in this field. The density of various types of hays as loaded on the mow hay drier and its effect on air flow through the hay at various depths and pressures is a problem worthy of continued research and consideration. It is the purpose of this paper to discuss some of the factors affecting the density of hay in the process of mow hay drying.

Before 1944 very little accurate information on the weight of hay per unit of area or volume, as loaded at relatively high moisture contents on mow hay driers, was available in agricultural literature. In 1944, Jennings[1] recorded the density of clover and alfalfa hay in 13 different tests, together with moisture contents at time of loading. In 1945 and 1946 other workers obtained the densities of various types of hays by recording the weights of hays at various depths as loaded, and determining the weight of hay at various depths as removed from the drier.

In 1945, the agricultural engineering department of the University of Wisconsin under the direction of F. W. Duffee, conducted tests on drying chopped clover and alfalfa hay in a solid concrete silo by forced-air circulation. Weights were recorded in total pounds of green hay loaded and in pounds of cured hay at six different levels, as it was removed from the silo.

In July of this year the agricultral engineering development division of the Tennessee Valley Authority conducted a test on drying chopped alfalfa hay in an octagonal plywood silo. Weights and volumes of four separate layers of green hay as loaded and cured hay as removed from the bin were obtained. Other more recent work on this subject may have been done, but it has not been made available to the author.

TABLE 1. ALFALFA HAY DENSITIES

Stage of drying	Depth, ft	Moisture content, %	Density, lb/cu ft	Volume, cu ft/ton	Form hay cured	Remarks
Start	12	59.4	10.68	187	Long	Heavy
End	8	20.0	6.94	288	"	"
Start	12	58.9	10.90	183	"	"
End	8	20.0	7.13	281	"	"
Start	8	48.6	7.88	253	"	2nd cutting
End	5¾	20.0	6.92	289	"	" "
Start	8	48.6	7.87	254	"	" "
End	6	20.0	6.77	295	"	" "
Start	8½	48.6	8.72	230	Chopped	2½-in cut
End	5¾	20.0	7.42	270	"	" "
Start	8¼	50.3	8.78	228	Long	99% pure
End	6	20.0	6.57	304	"	" "
Start	8	60.7	7.81	256	"	51% pure
End	5½	—	5.52	363	"	" "
Start	10	48.0	6.58	304	"	Heavy
End	7½	20.0	5.70	351	"	"
Start	8	43.2	6.72	298	Blocks	Late bloom
End	6½	20.0	5.87	341	"	" "
Start	9	40.8	9.40	213	Chopped	2½-in cut
End	7	20.0	8.93	224	"	" "
Start	8½	39.3	8.90	225	"	1½-in cut
End	7	20.0	8.15	246	"	" "

Table 1 gives a summary of some densities recorded for both green and cured alfalfa hay in recent tests when accurate weights and volumes of hay were obtained. It is significant to note from this summary that the densities recorded for settled barn-dried hay are much higher than the figure of 4 lb per cu ft (500 cu ft per ton) which is commonly used to estimate the tonnage of settled hay in stacks, ricks, and mows.

Table 2 shows densities of mow-cured hay as recorded by W. H. Sheldon and S. T. Dexter of Michigan State College.

Hay densities in these tests varied from 253 cu ft per ton for ladino clover of 50 per cent moisture content to 537 cu ft per ton for field-cured alfalfa-brome mixture of 19.4 per cent moisture content. Two lots of alfalfa-brome hay loaded to depths of 13¾ and 9 ft had densities of 413 and 411 cu ft per ton and average moisture contents of 38 and 30.8 per cent, respectively. The first lot of this hay was air blown intermittently for one week and continuously for two weeks. Densities of cured hay, when removed after 7½ months of storage, varied from 500 cu ft per ton in the top layer to 300 cu ft per ton in the bottom layer. The second lot, air blown for 10 days continuously, had an average density of 440 cu ft per ton when removed after one month storage. Apparently continuous blowing causes the hay to settle gradually in the mow to fairly uniform densities, whereas intermittent blowing results in more rapid and uneven settling. The greater depth of storage (13½ ft), as compared to 9 ft, accounts to some extent for the higher densities in the lower layer.

Field-cured alfalfa-brome hay (column 3 in Table 2), loaded at 19.4 per cent moisture content, had a density of 505 cu ft per ton when removed 22 days after storage. This lot of hay may be compared to the air-dried hay (column 2), as both lots were that taken from the same field and from adjoining windrows. The air-dried hay had an average density of 440 cu ft per ton as compared to 505 cu ft per ton of the field-cured hay.

Ladino clover, cut in early bud stage and containing 50 per cent moisture, had the highest density (253 cu ft per ton) of all hays tested. The physical characteristics of this type of hay, fine stemmed and leafy, coupled with relatively high moisture content, cause it to pack more tightly in the mow than other coarser, less leafy hays.

Factors Affecting Hay Density. There are many factors affecting the density of hays in the barn hay-drying process. The most important ones are as follows: Stage of maturity at time of cutting, moisture content at time of storage, kind of hay, depth of storage, method of harvesting and handling before storage, and method of handling in mow storage. A discussion of some of these factors as they apply to barn curing of hay follows.

Hay Density in Relation to Maturity. The stage of maturity when hays are cut is an important consideration in hay drying, both from the standpoint of the nutritional value of the finished product and the density of the hay mass as loaded on the drier. Hay cut in the early stages of growth is high in percentages of protein, minerals, vitamin and moisture content. The percentage of leaves is also higher than when cut in the later stages of development. Jennings recorded a maximum density of 14.6 lb per cu ft (137 cu ft per ton) for a clover mixture (80 per cent moisture content) first cutting, loaded to a depth of 4 ft in a 4x6-ft bin. Other experimental studies showed a density of 13.13 lb per cu ft (152 cu ft per ton) for a 2-ft layer of first cutting, 66 per cent moisture content alfalfa hay cut in early bloom. Density for a 12 ft depth of the same hay was 10.68 lb per cu ft, or 187 cu ft per ton of green hay as loaded. The corresponding density of an 8-ft depth of the same hay cured to 20 per cent moisture content was 6.94 lb

This paper was presented at the Third Barn Hay-Curing Conference sponsored by the American Society of Agricultural Engineers at Chicago, Ill., December, 1946.

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[1] Progress Report on Mow Curing of Hay by B. A. Jennings, Pub. No. 824, New York State College of Agriculture, department of agricultural engineering, New York.

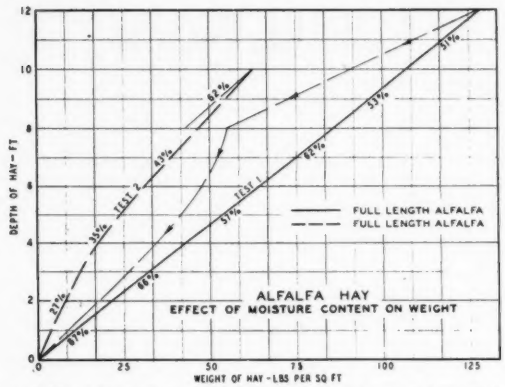


Fig. 1 Effect of moisture content on weight of hay per foot of depth

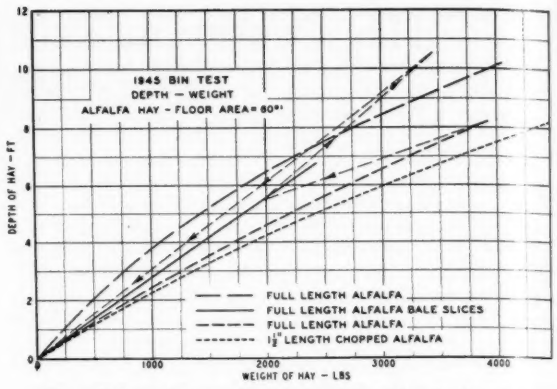

1945 BIN TEST
DEPTH — WEIGHT
ALFALFA HAY - FLOOR AREA = 60"
DEPTH OF HAY - FT
WEIGHT OF HAY - LBS
FULL LENGTH ALFALFA
FULL LENGTH ALFALFA BALE SLICES
FULL LENGTH ALFALFA
1½" LENGTH CHOPPED ALFALFA

Fig. 2 Relation between depth and weight of hay for four hay drier tests

per cu ft, or 288 cu ft per ton. In the light of such figures, it is evident that the capacity in actual tonnage of barn hay driers has been in many cases underestimated in the past.

Moisture Content. In general, for a given depth, hays at 50 to 60 per cent moisture content will have a greater mow density than those loaded at a lower water content. Fig. 1 shows the effect of moisture content on weight of hay per foot of depth and equal areas of loading for full-length alfalfa hay. Long hay with a moisture content varying from 67 per cent at the bottom to 51 per cent at the top had a greater density than long alfalfa hay loaded at 27 to 62 per cent moisture content. The straight line relationship indicated that the weight of hay increased in proportion to the depth in the case of the full-length alfalfa hay of high moisture content at bottom and a lower moisture content at top of the hay.

Kind of Hay. Hays with fine stems and a larger percentage of leaves by weight, such as alfalfa and ladino clover, have a tendency to pack more tightly in the mow than hays with large woody stems, such as soybean hay. Other factors, such as moisture content, stage of maturity, and rate of loading on the mow, have a greater effect on density than the particular kind of hay. Duffee at Wisconsin reported a mow density for a top layer of cured fine stemmed leafy alfalfa of 5.165 lb per cu ft and a density of 4.47 lb per cu ft for a layer of rather coarse and overripe clover hay immediately below the alfalfa.

Depth of Storage in the Mow. Fig. 2 shows the relation between depth and weight of hay for four different hay drier tests. The chopped alfalfa hay showed the greatest density for a given depth than any of the other hays tested. One reason for this high density was that this hay was cut in the prebloom stage and was thin-stemmed and leafy. Experimental studies indicate that, after the hay has settled in the mow and has reached the stability point in moisture content, it appears that the density of the hay varies little, if any, with depths up to 12 ft. This is indicated by the straight (dotted) lines on the graph. Data for these lines were obtained by recording weight of hay at successive depths as the hay was removed from the drier. For much greater depth of hay in the mow, the density of the lower layers of hay would probably be increased. Fig. 3 shows the relation between depth and weight of hay in another test. In this graph the solid line shows that the weight of hay increased approximately as the depth. The dashed line shows the weight of cured hay as removed from the drier. This data supports the previous statement, that density varies little with depth for depths up to 12 ft.

Table 3 shows the relation of density, moisture content, and air flow for the four tests shown in Fig. 2.

In all but one of the above tests there was a reduction in air flow for the same static pressure as the hay dried and settled. This means that the total resistance to air flow usually but not always increases as the hay dries. Air flow through the chopped

TABLE 3. RELATION OF DENSITY, MOISTURE CONTENT, AND AIR FLOW IN HAY

Test No.	Type of Hay	Date	Depth (approx.), ft	Weight, lb per cu ft	Moisture content, %	Cfm per sq ft at 1-in s.p.
1	Alfalfa, 51% Grass, 29% Weeds, 21%	5/19/45	8	7.81	60.7	30
		6/7/45	6	5.06		22½
2	Alfalfa ½ bloom ½ pod	7/11/45	10	6.58	48	32
		7/25/45	7½	5.75	20.8	28
3	Alfalfa Bale Slices	8/9/45	8	7.22	43.2	27
		9/4/45	6½	6.03	22.1	28½
4	Chopped Alfalfa 1½-in length	10/15/45	9	9.40	40.8	16
		11/7/45	7	8.70	17.6	10.9

TABLE 2. UNPUBLISHED DATA ON DENSITY OF MOW CURED HAY AT MICHIGAN STATE COLLEGE

Date put in	June 15-17, 1944	June 26-27, 1946	June 27-28, 1946	May 31-June, 1946
Kind of hay	Alfalfa-brome	Alfalfa-brome	Alfalfa-brome	Ladino clover
State of maturity	1/10 bloom	1/5 bloom	1/5 bloom	Early bud
Moisture content when stored, %	38 avg	30.8 avg	19.4 avg	50
Size of mow, ft	18x30	18x30	18x30	18x30
Depth when stored, ft	13¾	9	10¼	4½
Weight of hay stored, tons	17¾*	11.8*	10.3*	10.0
Density when stored, cu ft/ton	413*	411*	537*	253
Air blowing during storage	1 wk interim 2 wks cont.	Continuous 10 days	None	Continuous 2 weeks
Weather during storage	Very cold 1 wk about normal	Very dry	Very dry	Cold, damp
Date taken out	Feb. 1945	July 31, 1946	July 19, 1946	June 21, 1946
Depth just before removal, ft	10½	7½	8½	4
Amount of settling, ft	3¼	1½	1¾	½
Per cent of settling	23.4	16.7	16.7	11
Weight when removed, tons	12½	9.2	9.3	6.0
Density when removed, cu ft/ton	500, top ⅓ 400, middle 1/5 300, bottom ⅓	440 avg	505 avg	360 avg
Moisture content, %	12	11	11	17
Tons of water lost in storage	5.24*	2.6	1.0*	4
Condition of hay when removed	Slightly musty on top	Excellent	Excellent	17% musty, 83% bright green (turned brown by Sept. 1st)

*Based upon average moisture content at time of storage and assuming no loss of dry matter.

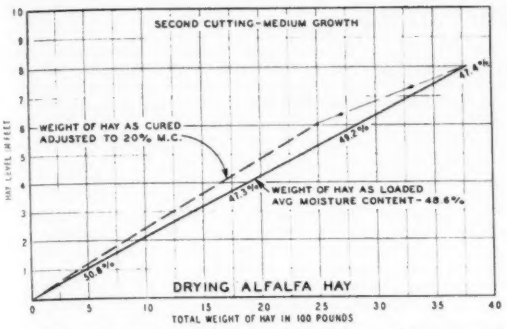


Fig. 3 Relation between depth and weight of hay in drying second-cutting alfalfa hay

hay was less for equal pressure than through the long hay and bale slices.

METHOD OF HARVESTING AND HANDLING BEFORE STORAGE

1 *Hay Loader, Wagon, and Fork.* In this method the hay is cut with a mower, allowed to wilt in the field swath and windrows, loaded on a wagon or truck by a hay loader, and hauled to the barn. It is then loaded onto the hay drier by a hay hoist and fork. This is a common method used in the southeastern states. Density of hay loaded depends upon the moisture content at the time of loading and to what depth the hay is loaded at any one time. In this method there may be greater packing in the center of the mow where the hay is dropped from the fork, if each load of hay is not manually spread evenly over the duct system. Even with such a procedure there is usually a greater density of hay in the center of the mow. Operators should be cautioned not to load too much hay of high moisture content on the mow at too rapid a rate. Excessive packing of hay will greatly increase the pressure required to force a given quantity of air through the hay. Guillou[2] states: "Piling twice as much hay on a unit of floor space should multiply by 5½ the pressure and power required to maintain a given air flow per ton of hay, even if the heavier loading does not compress the hay."

2 *Baled Hay.* In this method the hay is cut by mower, allowed to wilt in field swath, raked into windrows and usually baled with a field pickup baler. The baled hay is then hauled to the barn and placed on the hay drier by a conveyor or other method. Densities of the baled hay of 30 to 35 per cent moisture may run as high as 18 to 20 lb per cu ft. This entails the use of higher air volumes and pressures for an equal depth and quantity of hay than are used in drying long hay.

W. H. Hosterman, Production and Marketing Administration, U. S. Department of Agriculture, gives the following information on densities of field cured baled hay: "The number of cubic feet required for a ton of baled hay varies considerably, depending upon the type of bale and the tension on the hay press at the time of baling. The large five-wire, box-pressed bales average about 200 cu ft per ton. This type of bale is found in California and to a limited extent in New York state. The 17x22-in perpetual press bales vary from 100 to 150 cu ft per ton, while the 14x16-in and 16x18-in stationary press bales will vary from 150 to 175 cu ft per ton. The twine-tied bales will vary from 225 to 250 cu ft per ton."

3 *Chopped Hay.* In this method, the hay after being cut and raked into the windrows is chopped in the field by a pickup chopper and blown into a wagon. It is then hauled to the barn and blown into the mow. Density of hay in this form, for equal moisture content and depth of loading, may be greater than that of long hay, but not always. Some sources have stated that from 2 to 2½ times as much chopped hay as unchopped long hay can be stored in an equal space. Recent data at hand does not give support to this statement. Jennings loaded 688 lb of long clover hay in a 4x6-ft bin to a depth of 4 ft and 663 lb of chopped clover hay to the same depth in a bin of equal size. Density of the long hay was 7.2 lb per cu ft and that of the chopped hay was 6.9 lb per cu ft. At the University of Tennessee chopped alfalfa hay 8½ ft deep at 40 per cent moisture content had a green density of 8.9 lb per cu ft and a cured density of 8.15 lb per cu ft. Other authorities recorded densities of 7.88 lb per cu ft for long alfalfa hay at an 8-ft depth as compared to a density of 8.71 lb per cu ft for chopped alfalfa hay loaded to an equal depth.

[2] Forced Air Flow in Drying Hay by Rene Guillou, AGRICULTURAL ENGINEERING, November, 1946, vol. 27, no. 11, p. 521.

SUMMARY

1 A knowledge of the physical characteristics of hays is necessary to enable the research worker to better understand and solve the intricate problems in hay drying.

2 More study is necessary on the variations in density of hays in order to more intelligently design an efficient hay drier system.

3 Important factors involved in relation to hay density are maturity, moisture content, kind of hay, depth of storage, and methods of harvesting and handling before storage.

4 The weight of hay in a mow does not always increase in exact proportion to the depth. The moisture content of each successive loading is an important factor in the resultant depth-weight ratio.

5 After hay has settled in the mow and reached the stability point in moisture content, the density of the hay varies little with depth for depths up to 12 ft.

6 The total resistance to air flow usually but not always increases as the hay dries and settles.

7 Different methods of harvesting and handling hay affect densities of hay placed in the mow, but moisture content, depth and rate of loading cause wider variations in density.

8 Chopped hay for equal depths and moisture contents may have a greater density than long hay, but recent data indicate the difference in density is not as great as has been assumed.

Flow of Air through Chopped Hay

(Continued from page 204)

The straight line labelled "plenum" in Fig. 9 satisfies this equation. Other data taken simultaneously at various depths and also plotted in Fig. 9 indicate that within these limits and with this material, in the equation $V = Cp^n$, n remains essentially constant and C varies in an inverse ratio with the depth.

The data presented in Fig. 9 readily indicate why the early systems designed for an air flow of 10 cfm per sq ft at 0.75-in static pressure worked relatively well at shallow depths, but failed completely at greater depths. The pressure drop through 16 ft of hay plus the entrance loss from the plenum chamber through slatted floor in this case is 1.25 in of water.

Unless methods of reducing the density of chopped hay are forthcoming, attempts to force 15 cfm per sq ft through a 16-ft layer of chopped hay in a mow of any appreciable size seem to be rather wistful thinking, because to do this requires a 2-in static pressure. Therefore, it appears that experimental work should proceed along the following lines: system design in which passing air through great depths of hay is not necessary; elimination of side losses from the mow; field technique to reduce to a minimum the mow drying necessary, and methods of chopping and subsequent handling of the hay to reduce its resistance to air flow.

Greetings from China

To A.S.A.E. MEMBERS:

FROM the other side of the world we send you greetings. Our four-man Committee on Agricultural Engineering arrived in Nanking on February 13th. Perhaps the fact that we already miss our daily contact with many of you is the real reason for this letter; we don't want you to forget us.

Dr. and Mrs. J. B. Davidson and Mr. and Mrs. Howard F. McColly and their three children are living in a new duplex house at the National Agricultural Research Bureau, about 5 miles outside the city wall of Nanking. Mr. and Mrs. Edwin L. Hansen and their two children live at Nanking University, and Mr. and Mrs. Archie A. Stone at National Central University, which is also in the city of Nanking.

The National Agricultural Research Bureau is the counterpart of our own USDA agricultural research center at Beltsville, Md. Founded in 1932 it made rapid progress, but was almost totally devastated when the Japs invaded this region in 1937. At that time the staff moved to the interior, with what little equipment they could carry, and continued their work under the most difficult conditions. They moved back to Nanking in 1946 — after 8 years absence — and now rebuilding and rehabilitation is in evidence everywhere. The photographs (Figs. 1 and 2) show some of the destruction wrought by the Japanese and the new building just completed for housing our farm equipment. New buildings for other departments are going up also — "rising again" from the ashes and rubble of war.

We have been very favorably impressed with the character and technical ability of the agricultural leaders here. Dr. Tsur Yet Sen, the Minister of Agriculture is a graduate of Yale and formerly president of Tsing Hua and Yen Ching Universities. Dr. T. H. Shen, director of the N.A.R.B. earned his Ph.D. at Cornell University and Prof. F. C. Woo, the deputy director, took his master's degree from the University of Illinois. Prof. L. T. Woo, head of the department of agricultural engineering at N.A.R.B. is a former student of Profs. William Boss and A. J. Schwantes at Minnesota.

Dr. Y. H. Woo, president of National Central University is a noted physicist, who has worked with Dr. Arthur Compton of the University of Chicago. Dean Lo of the agricultural college of National Central is a graduate of Kansas State College. Mr. C. W. Chang, dean of agriculture at Nanking University, is a graduate of Cornell and a pioneer in agricultural education in China. All of these agricultural leaders and educators have given us a most cordial reception and enthusiastic support.

Our 3-year program will be a combination of research, demonstration, and teaching. A major objective of the program planned is to conduct complete crop-cycle demonstrations of American farm equipment and production techniques, to determine whether and how they can be profitably used under conditions here. Increased production *per man* is a definite goal. Yields *per acre* in China, with their meticulous hand methods, often equal or exceed ours, but production per man is very low. Prosperity is a condition, not alone of acres, but of men.

But even if such demonstrations should be successful, that alone would not be enough. We shall try also to lay a foundation upon which the continued improvement of production methods can be carried on. In brief, we shall try to initiate and encourage agricultural engineering, or as Ed Hansen so well puts it, we shall try to "sell" agricultural engineering.

Dr. P. C. Ma, director of rehabilitation for the Ministry of Agriculture, has asked us to cooperate with his division in their nation-wide program. We hope to do so, primarily by training operators who will act as leaders in the various communities where these rehabilitation projects will be located.

Our work in training agricultural engineers has already begun. The first students in all of China to study an approved professional curriculum recently reported to us. Our Committee was gratified to learn that they chose agricultural engineering because they had heard we were coming to China.

Their professor, Y. Chiang, is himself a graduate of National Central University, and took the long, wartime trek to Chungking where the colleges of agriculture kept on functioning despite lack of facilities and almost constant Jap bombing. Chiang is also a partner and the chief designer for the largest farm equipment factory in Nanking. It is a very small factory, if judged by U. S. standards, but they have more equipment than either Cyrus McCormick or John Deere had when they started.

These first students are now in their sophomore year. Mechanical engineering courses predominate in the first two years and courses in agriculture and agricultural engineering in the final years. The curriculum was patterned after those of leading agricultural colleges in the states. Our Committee will probably recommend some modifications, which we feel sure will be approved as "J.B." also has an official appointment as adviser on curriculums to the Minister of Education, Dr. Chu Chia-hua.

Thus we feel that we are preparing the soil and planting the tree of agricultural engineering in China. In fact, we have done so literally. At an impressive ceremony on March 24, which our Chinese friends arranged for us, each member of our Committee planted a tree at the entrance to our farm machinery building. When the Chinese students in agricultural engineering — both here and in the states — complete their courses, we hope to have a "home" ready for them in their chosen profession, with plenty of opportunity for real service to their country. What our committee can accomplish in a few short years will probably be little; but what these young men can do in the years to come is without limit.

So far we have made only a few observations of Chinese farm methods. But even these few may be of interest.

Fig. 3 shows a farmer preparing a seedbed with a swing-type spading fork (called T'ieh pa — literally, iron harrow). He was doing good work and was proud of it; said it was better work than that done by the water buffalo. But we measured the area he had done that day and found his daily capacity to be about 1/24 acre. At the lowest reported wage for farm labor in this region, it was costing him about $12 per acre to prepare his land. Also he said he would have to go over the ground again before it was ready for planting.

The water buffalo (Fig. 4) is pulling a 7-in plow, and we determined that he could plow about ½ acre per day. His "speed" is about one mile per hour. If he walked any slower he would stop. Water buffalo are scarce and expensive due to the destruction during the war; the present cost of a young work animal is said to be about $85 (U.S.). We have noted with much interest the harness used — a rope with a wooden yoke hung over the neck. The rope under the throat seems to us to be an efficient means of throttling the animal. Maybe that is one reason they must rest so often. When our dynamometer arrives J.B. plans to test the "drawbar pull" of these animals and determine just how much work they perform.

We have been much interested in the construction work going on — lots of it here at the Bureau and also in the city of Nanking. We are all agreed that the Chinese carpenters are mighty good craftsmen, considering the simple tools with which they work and the great amount of hand labor required when they saw the logs into boards "on the spot". Straw thatching is commonly used for roofs, although most of the better buildings and many of the smaller have tile roofs.

Farm houses in this area are of the better class. Walls are 12-in stone laid without mortar, and mud plastered inside. Wheat straw roof on pole construction is most common. Packed earth serves as the floor. The better homes are two rooms. A small *(Continued on page 210)*

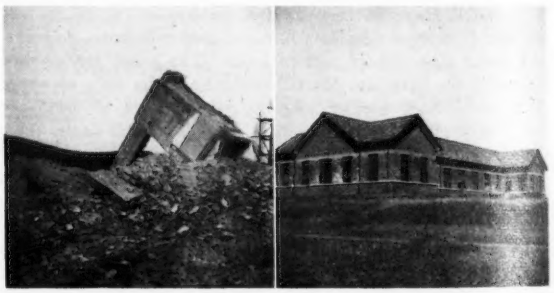


Fig. 1 ***(Left)*** **Former administration building of the (Chinese) National Agricultural Research Bureau, reduced to rubble by Jap bombs • Fig. 2** ***(Right)*** **The new farm machinery building of the N.A.R.B.**

Fig. 3 ***(Left)*** **Plowing with a swing fork (t'ieh pa) in China • Fig. 4** ***(Center)*** **Plowing with a water buffalo • Fig. 5** ***(Right)*** **A Chinese "sawmill" making boards the hard way**

RESEARCH NOTES

A.S.A.E. members and friends are invited to supply, for publication under this heading, brief news notes and reports on research activities of special agricultural engineering interest, whether of federal or state agencies or of manufacturing and service organizations. This may include announcements of new projects, concise progress reports giving new and timely data, etc. Address: Editor, AGRICULTURAL ENGINEERING, St. Joseph, Mich.

THE past year's accomplishments by four USDA research divisions of agricultural engineering were presented in a statement of highlights in research by A. W. Turner, assistant chief (in charge of agricultural engineering), of the Bureau of Plant Industry, Soils, and Agricultural Engineering, to the subcommittee on Agriculture of the House of Representatives Appropriation Committee at the annual hearings. Some of the work of the divisions has been mentioned in research notes in recent issues of AGRICULTURAL ENGINEERING. Future progress on continuing projects will also be reported from time to time and new projects announced as they are undertaken. The following brief highlights, as outlined by Mr. Turner, do not cover all studies in which the agricultural engineering divisions are now engaged, but they indicate the types of research under way and some of the measurable results:

FARM BUILDINGS AND RURAL HOUSING RESEARCH

1 *Farm Housing.* In cooperation with the Bureau of Human Nutrition and Home Economics, prepared M. P. (Miscellaneous Publication) 619, "Your Farmhouse—Planning Your Remodeling", and M. P. 622, "Your Farmhouse—Cutouts to Help in Planning". The "Your Farmhouse" series also includes "Planning Your Bathroom" and "Insulation and Weatherproofing", which are now ready for printing; popular bulletins on 14 other farmhouse problems are in preparation.

Obtained approval by a committee representing the agricultural colleges of the 12 northeastern States of eleven preliminary plans for farmhouses. The houses cover a wide range of income groups and construction materials; working drawings are completed for five.

2 *Dairy Cow Housing.* In cooperation with the Missouri Agricultural Experiment Station and the Bureau of Dairy Industry, completed the psychroenergetic laboratory at Columbia, Mo. This laboratory, housing two lots of 6 cows each, with temperature, humidity, and related factors controlled, will be used to determine housing requirements for dairy cows.

3 *Poultry Housing.* Completed, except for minor items of equipment, one of two 10-hen calorimeters for study of effects of temperature and other housing factors upon health, growth, and production. The work is in cooperation with the Bureau of Animal Industry.

4 *Farm Animal Shelters in Warm Climates.* In cooperation with the California Agricultural Experiment Station conducted exploratory studies on the environmental requirements of hogs. Data obtained will be used in developing means to protect animals from excessive heat.

5 *Corn Storage.* In cooperation with the Iowa and Illinois state agricultural experiment stations made tests to evaluate factors affecting storage and drying of corn and developed a new and valuable method of calculating changes of corn moisture content when air temperature, relative humidity, and rate of flow are known. This provides a scientific basis for design and operation of corn drying equipment and can be adapted to problems involving other grains. Work was financed in part by special research funds.

6 *Wheat Storage.* In cooperation with the Production and Marketing Administration, the Bureau of Entomology and Plant Quarantine, and the Kansas Agricultural Experiment Station completed field work on wheat storage studies furnishing data for improved grain bin design and management practices that reduce storage losses and supervision costs to a minimum.

7 *Potato Storage.* Submitted for publication a farmers' bulletin describing the most satisfactory types of storage houses and operating methods. The bulletin is based on research in five important late-crop potato areas.

8 *Apple and Pear Storage.* Issued Circular 740, "Cold Storage for Apples and Pears", and submitted for publication a manuscript, entitled "Coordinated Management for Harvesting, Storing, and Marketing Northwest Apples".

9 *Crop Storage in the South.* In cooperation with the University of Georgia resumed war-interrupted study of sweet potato storage and began study of conditioning and storing of blue lupine seed; submitted for publication a farmer's bulletin on storage of sweet potatoes, prepared in cooperation with the Division of Fruit and Vegetable Crops and Diseases.

10 *Plan Exchange.* In collaboration with a committee of agricultural engineers representing the 12 northeastern states, brought 42 farm building plans up to date for use in a revision of M. P. 278, "Plans of Farm Buildings for Northeastern States".

11 Furnished information regarding farm buildings in answer to about 10,000 requests.

FARM POWER AND MACHINERY RESEARCH

1 *Pest and Plant Disease Control Machinery.* Developed a self-powered insecticide duster and feeding unit in which the dust is fluffed up and a constant head maintained.

Fertilizer Distributing Machinery.

2 *With corn,* obtained highest yields (71 bu per acre) with fertilizer side-placed in bands, with special attachment. Usual farm practice with conventional planter gave a 22-bu lower yield.

3 *With peas,* obtained highest yield with fertilizer side-placed in single band, by special attachment. This placement gave 20 per cent greater yields than broadcasting.

4 *With lima beans* under irrigation, secured highest yield with fertilizer placed shallow at seed level near seed. This placement gave 40 per cent greater yield than deeper placement.

Southeastern Farm Machinery Investigations.

5 Developed belt-type, high-speed planter for planting shelled peanuts.

6 Devised pick-up unit for gathering tung nuts from the ground.

7 Developed portable tung nut huller for hulling the nuts as fed by the pickup unit.

8 *Sweet Potato Production and Harvesting Machinery.* Devised tractor cultivator equipment so that it would maintain the bed shape during cultivation and eliminate hand hoeing.

9 Developed new type transplanter which makes use of revolving disk for placing the draws at a uniform depth. Sixty per cent labor is saved in using this method compared with planting the ordinary way.

10 *Sugar Beet Production and Harvesting Machinery.* In sugar beet planter studies designed to increase stand, including about 40 planter combinations, the planter with double-disk furrow opener altered to give a rounded furrow bottom in place of the customary W shape and fitted with a straight steel delivery tube and special packing wheels proved best and increased the stand some 20 per cent.

11 *Sugar Cane Production and Harvesting Machinery.* Built experimental planter to plant seed cane in pieces of varying lengths. With this machine the stand was increased 20 per cent by using 24-in lengths and 36 per cent using 12-in lengths compared to the stand wherein ordinary cane lengths of about 48 in were used.

Cotton Production and Harvesting Machinery.

12 Worked out standardized arrangement of shovels on a tractor cultivator to facilitate cultivation and other mechanical operations. By setting the shovels flat and according to pattern this arrangement should make further attention in the field by the operator unnecessary.

13 Determined that proper use of the rotary hoe next to the row in early cultivation would materially reduce "damping off" of seedlings.

14 Made further determinations on direction and intensity of gas flame in flame cultivation of cotton, corn, and other crops.

MECHANICAL PROCESSING OF FARM PRODUCTS

1 Developed the cottonseed small-pipe pressure conveyor for handling seed in gins with reduced power.

2 Made ginning tests of Cooperative Cotton Improvement Project samples.

3 By use in commercial gins and tests by impartial engineers demonstrated that pressing cotton in standard density bales at gins decreases fire hazard.

4 Developed a sansevieria transplanter that saves a great amount of hand labor.

5 Worked out laboratory method of drying long fibers which gives much better fiber quality than processes now in use. The method is now ready for pilot-plant tests.

6 Found that use of combing attachments to fiber flax scutching machines resulted in large returns to producers and less hand labor.

7 Found that closed-top retting tanks reduce time of retting fiber flax.

8 Developed standard plans for poultry dressing plants after studies which showed a wide range of efficiency in such operations.

FARM ELECTRIFICATION RESEARCH

1 Through changes in tobacco barn ventilation, controlled temperature, use of insulation, and improved furnaces in curing bright-leaf tobacco, reduced coal consumption two-thirds (1,989 to 820 lb). Incidentally, tobacco barn fires cost North Carolina farmers two million dollars in 1946. Construction improvements, improvements in curing equipment, design, and controlled temperatures will reduce such losses.

2 Obtained data showing that mow-finished hay when fed to dairy cows produced 8.1 per cent more milk per acre than field-cured hay.

3 Found that use of artificial heat in mow-drying of hay shortens time of drying and increases quality of hay.

4 Completed arrangements for renewal of investigations of use of electric lights and traps in corn borer control in Indiana. The European corn borer adult moth, a night-flying insect, is attracted by electric lamps and may be killed by an electric trap before laying its eggs. In investigations interrupted by the war a 70 per cent reduction in borer population was effected.

5 Inaugurated a project cooperative with the Connecticut Agricultural Experiment Station to study methods and equipment for pasteurization to reduce milk-borne disease among farm families. Cases of undulant fever, due chiefly to drinking raw milk, increased from 1,502 in 1932 to 5,602 in 1946 (U. S. Public Health Service).

* * *

In order to expand and consolidate work on mechanization of peanut production and harvesting, the Division of Farm Power and Machinery, USDA, is now cooperating in a project centered at the Georgia Coastal Plain Experiment Station, Tifton, Ga. The agricultural engineering department of the University of Georgia and the agricultural experiment station at the University are also cooperating. William D. Kenney is the USDA-Georgia agricultural engineer assigned to this work. Georgia is Mr. Kenney's native state, and he is a graduate of the University of Georgia in agricultural engineering.

Objectives of the studies are to develop and improve the effectiveness and efficiency of methods and machines for producing, harvesting, curing, picking, and farm handling of peanuts. In addition to reducing labor requirements per unit, it is hoped to improve the quality of hay and peanuts and to develop cultural practices which will maintain or improve soil fertility.

A detailed survey will be made of current cultural practices to determine the man-hour and equipment cost for the various operations by the different methods. Specialized local practices will be observed and those that might have merit will be studied and recommended if they show advantages in economy of cost, labor, or use of land. Factors needing special attention will be isolated and given needed considerations.

Although all phases of production need to be studied, the immediate need is refinement of the harvesting and curing practices. These will be given concentrated attention at the beginning of the study.

Greetings from China

(Continued from page 208)

one for sleeping while the other has the kitchen stove in one corner, the donkey and pig in the adjacent corner and a pile of fuel and feed in between. Farm implements hang from the roof members. Such a house, 24x30 ft, costs about 3½ million dollars ($300 U. S.).

Of course, we have our "budget" problems too, the same as in the states. But our friends here have been most liberal and generous. Our annual allocation has been set at $600,000,000. Before you pass out with shock from this figure, get out the slide rule and translate it into U.S. dollars at the ratio of 12,000 to 1. You will find that we have been pretty well provided for, especially so when most of our equipment has been donated by our sponsor, International Harvester Co., and several other cooperating manufacturers.

With many good friends here and at home, with good equipment and financial support, we believe we are off to a good start. We think the trees we planted on March 24th are well rooted; that they will be tended and nourished by the young Chinese agricultural engineers, from here and abroad, who will follow us. We hope these trees may thrive and grow until the techniques of China's greatest industry — agriculture — will be based on agricultural engineering, which seeks not only profit for the producer but a higher standard of living for all.

Best regards to all,

H. F. McCOLLY
E. L. HANSEN
J. B. DAVIDSON
ARCHIE A. STONE

Committee on Agricultural Engineering
National Agricultural Research Bureau,
Shaolingwei, Nanking, China.

Design of Barn Hay-Curing Systems

(Continued from page 194)

partly filled. For example, suppose 5 or 6 ft of hay is put in the first day. Blowing must be started and something must be done to prevent most of the air from going out the top. We got around this by piling the first hay against and above the duct, leaving the sides very low. As might be expected, this made the hay very difficult to remove. To avoid this difficulty a better method would probably be to keep the first hay nearly level and stop off the upper 3 or 4 ft of the duct with sheets of plywood or heavy paper. When the mow was nearly full this stopping would be removed.

The single high duct is an easy one to build, and is believed to be an improvement both as to air distribution and lower resistance, hence giving more air and faster drying. If made about 6 ft high, it probably is effective for a depth of 14 or 15 ft. For greater depths than this, it is likely that some other method of distribution may be needed, perhaps a two-level system of ducts, if a practicable method of using two-level ducts can be devised.

Ag Engineer Moves Earth

TO THE EDITOR:

ABOUT three years ago I started in business for myself. We had a Ford tractor and a John Deere tractor with a disk tiller for terracing. We then saw the need for doing other soil-saving services. As a result we have track-type tractors with bulldozers and a scoop for moving earth. We fill ditches, build dams, remove hedge and trees, and do some road work.

We have a Caterpillar No. 12 motor grader for building terraces which is very satisfactory. We also have a Whirlwind terracer and a Ford terracer.

At present we employ an agricultural engineer and three to five equipment operators depending on the season of the year.

Most of our work at present is done locally in Mills County, Iowa. But we hope to expand in the future to cover southeastern Iowa.

HOWARD T. PALMER

Agricultural engineer and owner
Palmer Terracing Company
Malvern, Iowa

Color for Safety Warning

TO THE EDITOR:

I HAVE noted in recent issues of AGRICULTURAL ENGINEERING the comments on safety in the operation of farm machinery.

The comment made on the importance of education for safety seems to indicate the most prolific source of safety advancement. Twenty years of personal experience in the development of corn pickers, combines, and other power machinery leads me to believe that operators become indifferent to hazards and are prone to remove shields if they are the least bit in the way.

I wonder if color warnings might not be utilized to some extent as is now being done in the industrial field. That is, the frames of machines such as punch presses are painted green or some other subdued color, and controls are painted some bright color that stands out. Also, moving parts such as the ram are red or orange, suggesting danger.

It might be difficult to employ this idea on many farm machines because of the tendency of some companies to paint an entire implement in one vivid color. However, a corn picker with orange or red moving parts, and with the shield and frame parts green or gray, might have some effect in keeping operators alert to the dangers that lurk in these machines.

R. I. DENNEY

Chief engineer
New Method Equipment Co.

Black Eye for a Blessing?

TO THE EDITOR:

WHILE on a trip recently I had a very interesting discussion on barn hay drying and the progress that has been made up to this time. One agricultural engineer mentioned that of all the installations he had made, only two have been duplicates. This indicates that we have a big job ahead to promote successful installations of this equipment.

From all I can learn, it would seem to me that the way barn hay drying is now being promoted may tend to give it a black eye, because most of the fan manufacturers are selling the market through their industrial sales organizations, which are not properly equipped with technical knowledge to do anything for the farmer other than to sell him a fan.

Barn hay curing is one of the greatest blessings that has yet come to the farmer. The fact that he can save enough money, that would otherwise be spent for protein feeds, to pay for a hay drier in one year or less, shows great possibilities for this process. I hope that manufacturers do not get too many inexperienced men in the field who will kill the farmers' enthusiasm for barn hay curing.

I believe it would be wiser if something could be done on a national scale to change the present method of distributing barn hay drying units, which require engineering experience to make sure that they are properly installed.

K. W. WESTERBERG

Farm Engineering Sales, Inc.

New Federal and State Bulletins

"Comparison of Different Methods of Harvesting Cotton," by H. P. Smith, chief, division of agricultural engineering, and others, is published as Bulletin No. 683 of the Texas Agricultural Experiment Station.

"Mechanical Harvesting of Corn" by H. P. Smith and J. W. Sorenson, Jr., division of agricultural engineering, is mimeographed as Progress Report 1063 of the Texas Agricultural Experiment Station.

"A Practical Laboratory Study Carburetor," by J. R. W. Young, has been published in mimeographed form by the department of agricultural engineering, University of British Columbia.

"The Efficient Use of Portable Fans" by E. G. Smith. Texas Engineering Experiment Station Bulletin, Bulletin No. 95 (1946).

A.S.A.E. Annual Meeting Program

Benjamin Franklin Hotel, Philadelphia, Pa. — June 22 to 25, 1947

THE 1947 annual meeting of the American Society of Agricultural Engineers — the Society's 40th annual meeting — will be held June 22 to 25 at the Benjamin Franklin Hotel in Philadelphia, Pa. Arrangements for the program and other attractions of the meeting are now practically complete, and a brief review of them follows:

Sunday, June 22. Meetings of the Council and the Cabinet will be held during the forenoon and afternoon of this date. Registration will start at 2:00 p.m. on the mezzanine floor of Benjamin Franklin Hotel.

The Pennsylvania Section of the Society, which is acting as host at this meeting, is arranging a complimentary buffet supper for Sunday evening, which will be followed by an interesting program of entertainment.

Monday June 23. The regular meeting sessions will open Monday forenoon, June 23, with concurrent Power and Machinery, joint Farm Structures and Rural Electrification, and Soil and Water programs.

The Power and Machinery program will be devoted exclusively to grass and weed control with flame and chemicals with papers on field methods of flame cultivation by W. E. Meek, U. S. Department of Agriculture, user experiences with flame cultivators by T. L. Baggette, New Holland Machine Co., mechanical features of flame cultivators by H. C. Gotcher, Gotcher Eng. & Mfg. Co., and on new use of chemicals by H. T. Barr and Dr. C. A. Brown of Louisiana State University.

The joint Farm Structures and Rural Electric program will be devoted entirely to tobacco handling and curing, with a paper on the engineering phases of curing bright leaf tobacco by Dr. Oral A. Brown, U. S. Department of Agriculture, and N. W. Weldon, North Carolina Department of Agriculture, and a second paper on the handling and curing of burley tobacco by J. B. Kelley, University of Kentucky.

The Soil and Water program will be devoted exclusively to the general topic of agricultural hydrology. Three formal papers are scheduled — one on agricultural meteorology by Jerome Namias, U. S. Weather Bureau, another on flow of water through soil by C. S. Slater, U. S. Soil Conservation Service, and the third on how to use statistics by Dr. Henry Hopp, U. S. Soil Conservation Service. This program will also include reports of committees and subcommittees as follows: agricultural meteorology, agricultural hydrology, soil-plant-water relations, evaporation, and ground water. The program on agricultural hydrology will be continued at an evening session the same day.

The first general session of the meeting will be held at 2:00 p.m. on Monday, June 23. The session will be opened by the chairman of the Committee on Arrangements, Paul J. Newton, followed by a preview of the program of the entire meeting by the chairman of the Meetings Committee, H. E. Pinches. The President's annual address will then be presented by Dr. Mark L. Nichols, assistant chief (in charge of research), U. S. Soil Conservation Service. Dr. Nichols' address will be followed by an address by Dr. R. W. Trullinger, chief, Office of Experiment Stations, USDA, on agricultural hydrology, and an address by Dr. R. E. Moore, Office of Foreign Agricultural Relations, USDA, on the possibilities of agricultural engineering in Latin America.

Following this program the Society's annual business session will be held.

The evening of Monday, June 23, has been set aside for a series of round tables and technical programs by divisions, committees, and other groups in the Society, including the College Division, Soil and Water Division, and several committees.

The Soil and Water program for Monday evening, a continuation of the forenoon program, will include two papers, one on analysis of surface runoff by W. D. Potter, U. S. Soil Conservation Service, and the other on dependable precipitation by H. K. Rouse, also of the SCS. An illustrated lecture on erosion phenomena about Paricutin, Mexico, will be delivered by Dr. W. C. Lowdermilk, assistant chief, Soil Conservation Service. In addition, the program will include two subcommittee reports, one on runoff by D. B. Krimgold, and another on watershed studies by L. L. Kelley, chairmen, respectively, of these subcommittees.

Tuesday, June 24. The forenoon of Tuesday, June 24, will feature three concurrent programs: Power and Machinery, Farm Structures, and Soil and Water.

The Power and Machinery program will be in the nature of a discussion panel on the general topic "Taking Stock of Farm Power and Machinery Research." The speaker panel will include K. W. Anderson, Deere & Co.; E. W. Tanquary, International Harvester Co.; A. W. Turner, U. S. Department of Agriculture, and L. W. Hurlbut, Purdue University.

The Farm Structures program for the same period will include four papers as follows: Asbestos Cement Roofing and Siding by M. V. Engelbach, The Rubberoid Co.; Withdrawal Resistance of Roofing Nails by Henry Giese, Iowa State College; Selection and Application of Asphalt Roofing by J. L. Strahan, Asphalt Roofing Industry Bureau, and Framing Farm Barns by R. A. Glaze, Weyerhauser Sales Co. A motion picture, entitled "The Paint Film," produced by the National Paint and Varnish Manufacturers Assn., will be shown at this session.

The Soil and Water program for Tuesday, June 24, will include papers on results of land use practices and erosion from agricultural watersheds by L. L. Harrold, U. S. Soil Conservation Service; the organizatiaon of Missouri terracing contractors by Marion W. Clark, University of Missouri; a national terracing contest by R. C. Hay, University of Illinois, and the application of light-weight portable irrigation pipe by F. W. Peikert, Michigan State College.

The second general session of the meeting will be held on Tuesday afternoon, June 24, with addresses by W. A. Roberts, president, Farm Equipment Institute, and vice-president, Allis-Chalmers Mfg. Co., and general manager of that company's tractor division, and by Dr. F. A. Brooks, research agricultural engineer, California Agricultural Experiment Station. Both addresses will deal mainly with the general subject of agricultural engineering research.

Following the Tuesday afternoon general session, and an early dinner, a fleet of buses will take those attending the meeting to Longwood Gardens, estate of Mr. Pierre du Pont, for an evening's entertainment.

Wednesday, June 25. The entire day of Wednesday, June 25, will be devoted to concurrent technical programs. The forenoon programs will include Farm Structures, Rural Electrification, and Soil and Water.

The Farm Structures program will include three papers: Safety in and Around Farm Buildings by C. L. Hamilton, National Safety Council; Safe Lightning Protection by R. D. Brenemann, Security Mfg. & Contracting Co., and Sanitary Requirements for Dairy Buildings by Harold B. Robinson, milk specialist, U. S. Public Health Service.

The Farm Electrification program for the same period will be devoted largely to research subjects, with a paper on correlating research programs by W. C. Wood, the W. C. Wood Co., Ltd.; another on rural electrification research by T. E. Hienton, U. S. Department of Agriculture, and a third on recent developments in the protection of farm crops from frost damage by the use of radiant energy by A. W. Farrall, C. N. Hansen, and F. J. Hassler, Michigan State College.

The Soil and Water program for Wednesday forenoon includes a paper on an experimental mulch tiller-planter for erosion control by R. R. Poynor, International Harvester Co.; drainage operations of the SCS by J. G. Sutton, U. S. Soil Conservation Service; the work of the practicing engineer in drainage and supplemental irrigation by W. H. Klingner of McCann & Klingner, Engineers; water control in the Florida Everglades by L. A. Jones, U. S. Soil Conservation Service, and a committee report dealing with depth and spacing of tile drains by Fred F. Shafer, drainage engineer.

The concurrent programs for the afternoon of Wednesday, June 25, are four in number: Power and Machinery, Rural Electric, Farm Structures, and Soil and Water.

The Power and Machinery program will be devoted exclusively to truck farming mechanization and will include papers on multiple-row equipment for truck farming by C. J. Allen of the S. L. Allen & Co., the application of rotary tillage in commercial truck farming by Mando S. Ariens of the Ariens Co., and an illustrated talk on mechanization of the King Farms by A. C. Thompson, manager of that organization.

The Rural Electric program includes a paper on The Heat Pump-Heating by Refrigeration by D. W. Zastrow, REA; one on heating cable to control moisture in poultry litter, and a third on electric motor controls by B. P. Hess, Westinghouse Electric Corp.

The Farm Structures program for the same period is to be devoted to the general topic "Farm Structures Research Programs," with a panel of speakers consisting of E. D. Anderson, Republic Steel Co., D. G. Carter, University of Illinois; Henry Giese, Iowa State College; H. E. Besley, Rutgers University, and R. H. Driftmier, University of Georgia.

The Soil and Water program for Wednesday afternoon will be devoted exclusively to the subject of farm ponds and reservoirs, one paper of which will be on the subject of essential requirements and basic structural types of farm reservoirs by Robert S. Calkins of the U. S. Soil Conservation Service. Arrangements are being made for other papers to be presented on this program.

The high point of the entire meeting will, as usual, be the A.S.A.E. annual dinner scheduled for the evening of Wednesday, June 25, with Paul J. Newton acting as master of ceremonies.

The principal feature of the dinner will be the annual award of gold medal and other awards to be made by the President of the Society.

In addition to the regular Society meeting program, a special program is being arranged for members of A.S.A.E. student branches, including student members of the Society, by the Committee on Student Branches headed by F. W. Peikert. This program will include a complimentary dinner given to the students by the International Harvester Co., on Monday evening, June 23.

Information regarding the program or other arrangements for the A.S.A.E. annual meeting will be gladly funished on request to the headquarters of the Society, Saint Joseph, Michigan.

NEWS SECTION

A.S.A.E. Officers for 1947-48

AS a result of the regular election of officers of the American Society of Agricultural Engineers conducted recently by letter ballot, the following have been elected and will take office at the close of the Society's annual meeting to be held at Philadelphia in June.

President — George A. Reitz, manager, farm industry division, General Electric Company.

Councilors (3-year term each) — Walter W. Weir, drainage engineer, division of soils, University of California, and Earl D. Anderson, agricultural engineer, agricultural extension bureau, Republic Steel Corporation.

The new Council of the Society for the year 1947-48 will include the above-named officers together with the following: J. D. Long, and M. L. Nichols, past-presidents; and W. L. Coultas, Henry Giese, C. N. Hinkle, and P. T. Montfort, councilors.

The newly elected Nominating Committee of the Society consists of W. G. Kaiser (chairman), I. D. Mayer, and W. L. Zink. Members of the Society are invited to send any member of the Nominating Committee such suggestions as they may have for nominees for the elective offices of the Society in the next annual election of officers, to be held early in 1948.

Dr. Trullinger Takes on New Duties

ANNOUNCEMENT is made by the Secretary of Agriculture of the appointment of Dr. R. W. Trullinger, chief, USDA Office of Experiment Stations, to the position of assistant administrator of the Agricultural Research Administration.

Dr. Trullinger will continue as chief of the Office of Experiment Stations, but the new arrangement provides for bringing the Office into closer contact with the over-all planning of research in the Department of Agriculture.

Dr. Trullinger came to the Office of Experiment Stations in March, 1912; and except for two years' military service in World War I has been employed there continuously ever since. He became assistant chief of the Office in August, 1938, and chief in August of last year. He is a native of Iowa and a graduate of Iowa State College. He holds a professional degree of agricultural engineering and an honorary degree of doctor of engineering.

Oklahoma Appoints Schroeder

ANNOUNCEMENT is made by the divisions of agriculture and engineering of the Oklahoma A. & M. College, Stillwater, of the appointment of Ervin W. Schroeder as professor and head of the department of agricultural engineering at that institution. At the time of his appointment, Mr. Schroeder was on the staff of the agricultural engineering development division of the Tennessee Valley Authority, and prior to that a member of the agricultural engineering staff of Pennsylvania State College.

Engler Heads A.S.A.E. Southwest Section

KYLE ENGLER, head, agricultural engineering department, University of Arkansas, was elected the new chairman of the Southwest Section of the American Society of Agricultural Engineers at a meeting of the Section held at the Grim Hotel in Texarkana, Texas, April 4 and 5. Other officers elected were: Vice-chairman, R. H. S. Henderson, assistant manager, Dallas (Texas) branch, Tractor Division, Allis-Chalmers Mfg. Co.; secretary-treasurer, Harold T. Barr, head, agricultural engineering research, Louisiana Agricultural Experiment Station.

The meeting was well attended, with a registered attendance of 86 persons, including both members and non-members of the Society. Special credit for the success of the meeting is due to the outgoing officers—Roy E. Hayman, chairman: Kyle Engler, vice-chairman; R. H. S. Henderson, secretary-treasurer, and F. R. Jones, chairman of the program committee.

During the business session of the Section it was voted to invite the Society to hold an annual meeting in the Southwest, and the incoming Section chairman was instructed to take steps to see that such an invitation was presented to the Society at its next annual meeting.

New England Electrification

THE Eighth Annual Rural Electrification Conference, sponsored by the Farm Electric Service Committee of the New England Council, in cooperation with the University of New Hampshire and with agricultural engineers in the area, was held at Durham, N. H., March 31 to April 2.

A.S.A.E. members on the program included Ralph J. Bugbee, Walter Bodwell, and J. H. Bodwell as session chairmen; G. M. Foulkrod on the "4-H Better Methods Program", also as a banquet speaker; E. W. Foss on "Hay Finisher Experiences," Wm. A. Junnila on "Poultry House Ventilation," Harold Todd on a "Silo Unloader," and F. L. Rimbach as moderator of an open forum on "The Development of Rural Electrification in New England."

These men shared the program with a notable list of other leaders in New England, including Governor Charles M. Dale, of New Hampshire, other administrators of the University and the state, utility executives, and several prominent men in farming and in farm organizations.

A.S.A.E. Meetings Calendar

May 16 and 17 — Virginia Section, Hotel Roanoke, Roanoke, Virginia

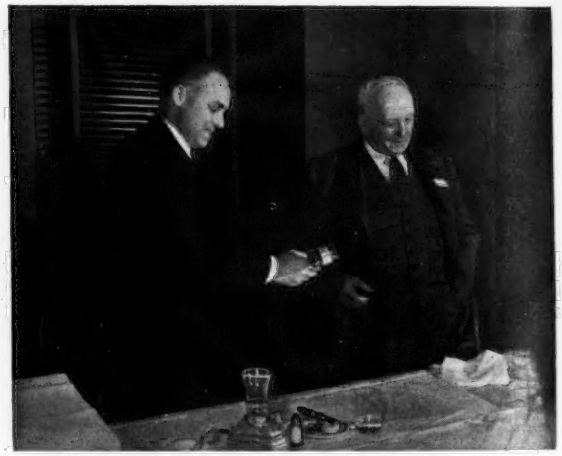
May 17—Michigan Area Section, 6600 East Jefferson, Detroit

May 22—Minnesota Section, Coffman Memorial Union, University of Minnesota, Minneapolis

June 23 to 25—ANNUAL MEETING, Benjamin Franklin Hotel, Philadelphia.

October 23 and 24 — Pacific Northwest Section, Davenport Hotel, Spokane, Wash.

December 15 to 17—FALL MEETING, Stevens Hotel, Chicago.



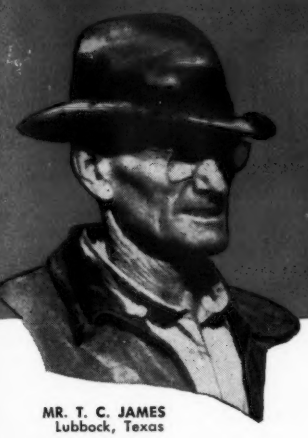
A Gavel with a History

In this picture E. W. Hamilton — one of the grand old men of A.S.A.E, who attended its organization meeting in 1907 and who served a term as treasurer of the Society in its early days — is shown (right) presenting a gavel with a history to June Roberts, newly elected chairman of the Pacific Northwest Section of A.S.A.E., at the dinner held in connection with the Section's organization meeting at Portland, Ore., October 31 and November 1, 1946.

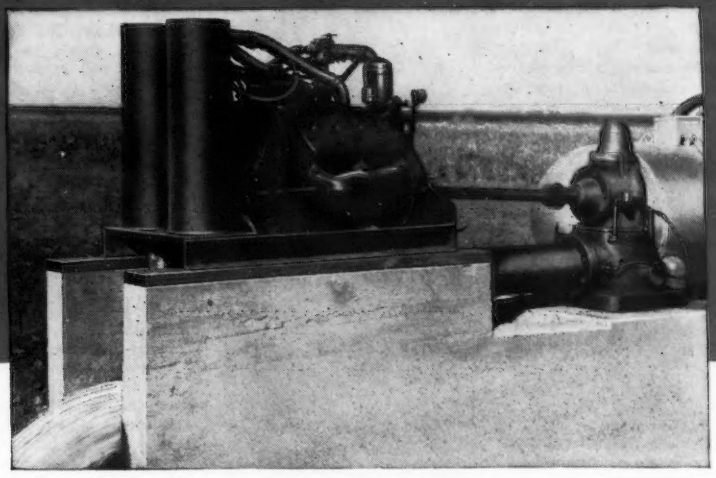
Here's the history behind the gavel: At the time of the organization meeting of A.S.A.E. at Madison, Wis., in December, 1907, there lived in that city one Bascom B. Clarke, widely known in the farm machinery field as the editor and publisher of the publication "American Thresherman". Mr. Clarke took a keen interest in the meeting of budding "agricultural engineers", and during the meeting, when their efforts to reach a decision on a name for the organization appeared about to be reaching a stalemate, "B.B.", as he was affectionately called, came forward with the suggestion that it be named the "American Society of Agricultural Engineers." The suggestion supported by convincing reasons soon broke the deadlock, and the name was overwhelmingly adopted for the infant engineering society. Mr. Clarke was later elected the first honorary member of the Society.

But here is where the gavel comes in: One of Mr. Clarke's hobbies was turning gavels on his wood-turning lathe. Mr. Hamilton came into possession of one of them — a most attractive one, by the way — and, after having an appropriately engraved silver plate mounted on it, it was his pleasure to present it to the first chairman of the newly organized Pacific Northwest Section, to be passed along to succeeding chairmen of the Section as they take office in the years to come.

Wouldn't power like this do a real job on YOUR job?



MR. T. C. JAMES
Lubbock, Texas



This Ford V-8 engine has been in continuous service since 1941. It irrigates 125 acres planted to cotton and grain. Average fuel cost is 27 cents per hour, using butane gas.

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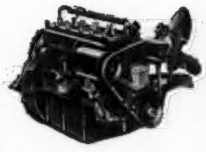
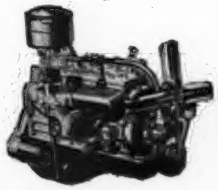


THE 40-H.P. FOUR
119.5 cubic inches displacement



THE 90-H.P. SIX
226 cubic inches displacement

THE 100-H.P. V-8
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A.S.E.E. Meets in June

THE next annual meeting of the American Society for Engineering Education will meet at Minneapolis, Minn., June 18 to 21. A special agricultural engineering program will be offered in connection with this meeting, arrangements for which are in charge of A. W. Turner, chairman, and H. J. Barre, secretary of the Agricultural Engineering Division of A.S.E.E.

The Agricultural Engineering Division will sponsor programs two sessions during the meeting. Chairman Turner states that agricultural engineering membership in A.S.E.E. has nearly doubled during the past year, and he urges that as many agricultural engineers as possible plan to attend the meeting. He points out that membership in and attendance at A.S.E.E. meetings provide excellent opportunity for agricultural engineers to gain recognition in the engineering education field as a whole. The meetings of A.S.E.E. provide sessions not only of the regular groups of engineering educators but also of the supporting groups such as mathematics, English, foreign languages, cultural education methods, engineering drawing, engineering economics, physics, chemistry, etc.

The first agricultural engineering session of the A.S.E.E. meeting is scheduled for Wednesday afternoon, June 18. Dr. H. J. Barre of Purdue University will address the meeting on agricultural engineering research as a basis for meeting requirements for an advanced degree in agricultural engineering. Dean Roy M. Green of the school of engineering, University of Nebraska, will talk on the place of engineering experiment stations in agricultural engineering, and R. H. Driftmier of the University of Georgia will report the results of a survey of agricultural engineering projects to determine the degree of agricultural and engineering sciences included in such projects. The program for this session also lists informal discussions by L. J. Fletcher, Caterpillar Tractor Co.; R. A. Glaze, Weyerhaeuser Sales Co.; D. A. Milligan, Harry Ferguson, Inc.; Dean of Engineering H. A. Curtis, University of Missouri; Dean of Engineering H. B. Dirks, Michigan State College, and Dean of Agriculture C. H. Bailey, University of Minnesota.

The second agricultural engineering program is scheduled for Friday afternoon, June 20, which will begin with a luncheon at noon. The speaker at the luncheon will be A. W. Farrall, head of the agricultural engineering department at Michigan State College, who will discuss most effective utilization of the fundamental engineering subjects in agricultural engineering terminal courses. This will be followed by informal discussion based on various subject matter phases, as follows: Farm Buildings—S. A. Witzel, University of Wisconsin; Farm Electrification — T. E. Hienton, U. S. Department of Agriculture; Power and Machinery — Hobart Beresford, Iowa State College; Rural Industries — W. M. Hurst, U. S. Department of Agriculture; Soil and Water — A. J. Schwantes, University of Minnesota, and Farm Safety — Frank J. Zink, consulting agricultural engineer.

Further details regarding the A.S.E.E. program as a whole may be obtained by writing direct to F. L. Bishop, secretary, A.S.E.E., University of Pittsburgh, Pittsburgh 13, Pa.

Refrigeration Publications Available

LAST year the American Society of Agricultural Engineers and the American Society of Refrigerating Engineers entered into an exchange arrangement which offers the members of one society the privilege of purchasing any or all of the publications of the other at the regular membership rates of that society.

The A.S.R.E. now offers the A.S.A.E. members the following publications at the membership rates indicated:

Refrigerating Engineering, monthly magazine and official publication of the A.S.R.E., completely covers every aspect of refrigeration and air conditioning. It is the most reliable source for comprehensive, impartial information about the latest, proved scientific solutions to refrigeration problems and air conditioning of all kinds. The annual subscription price is $3.00 in the U.S., $4.00 elsewhere. The membership rate is $2.50 in the U. S., $3.50 elsewhere.

Refrigeration Abstracts, a new publication containing brief condensations of all articles of refrigerative interest appearing in hundreds of periodicals and reports published internationally on refrigeration and allied subjects. It is issued five times a year and subscriptions can be predated to start with the first issue published in January, 1946. The annual subscription price is $7.00 in the U.S., $8.00 elsewhere. The membership rate is $5.00 in the U.S., $6.00 elsewhere.

REFRIGERATION DATA BOOK.

The Applications Volume of this data book contains up-to-date and authoritative information on all applications of refrigeration and air conditioning — data that will facilitate your work and keep you informed of all the latest developments in the industry. The second edition was published in 1946 and sells for $5.00 a copy in the U.S., $5.50 elsewhere. The membership rate is $3.00 a copy in the U.S., $3.50 elsewhere.

The Basic Volume of this data book is the standard illustrated reference work of the refrigeration and air-conditioning industry. It contains theoretical explanation of the prin- *(Continued on page 216)*

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WHY go through haying and silage harvesting the old hay fork way when you can do these jobs so much easier and faster the FOX Way?

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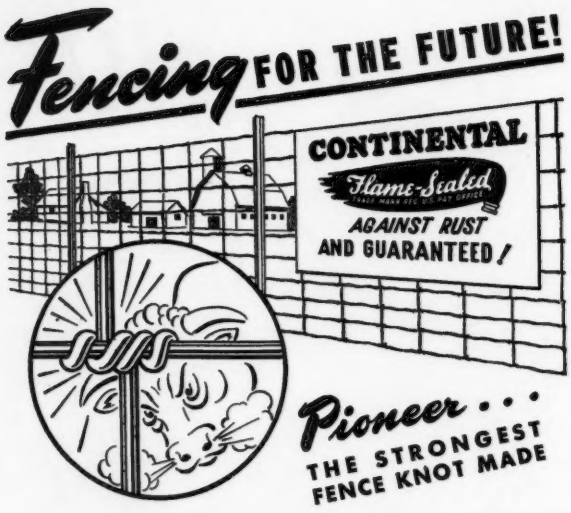

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● Better farming methods and permanent pasture programs will require new and better fence. Continental Fence has many features to give it longer life and greater strength. It is made of copper steel wire that carries a heavy, uniform zinc coating, FLAME-SEALED for extra protection against rust. Continental Fence with the PIONEER KNOT is semi-flexible to withstand crowding of livestock without folding or buckling of the stay wires. This knot will not unwrap and actually tightens under strain. Only Continental FLAME-SEALED Fence with the PIONEER KNOT can give you all these advantages.

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ciples of refrigeration and air conditioning with unique analyses examples, tables and charts, problems and their solutions. The fifth edition (1942) is now in its fourth printing. A limited run will be available on July 1, 1947, to sell for $4.00 a copy, while it lasts. A new sixth edition is now in preparation but will not be released until 1948. The membership price on the old book is $2.50 in U. S., $3.00 elsewhere.

Descriptive folders on the above-named publications of the American Society of Refrigerating Engineers will be mailed on request. Orders must be on a strictly cash basis to make it possible to offer the A.S.R.E. publications at such low prices. Orders for the above publications should be sent direct to the A.S.R.E., 40 West 40th Street, New York 18, N. Y.

Basic Farm House Plan Project

A SPECIAL project to develop sound basic farm house plans during the next several months has been initiated at the University of Illinois through the cooperation of its college of agriculture, its Small Homes Council, and the "Farm Journal."

Deane G. Carter and Keith Hinchcliff are representing the agricultural engineering department of the college on the directing committee, along with representatives of home economics, landscaping, and architecture. This committee will undertake to agree on basic principles of design to meet the requirements of farm family living, and to express them in a design or designs which can be embodied in plans otherwise varied to suit individual requirements and preferences.

The project is scheduled to be completed by late summer.

Clark Chairman Missouri Section

AT A meeting of the Missouri Section of the American Society of Agricultural Engineers held in Kansas City, April 17 to 19, Elmer F. Clark, agricultural engineer, Butler Mfg. Co., was elected chairman of the Section, succeeding J. C. Wooley. Three vice-chairmen were elected: M. M. Jones, professor of agricultural engineering, University of Missouri; H. E. Everett, editor and general manager, Implement and Tractor, and B. G. Perkins, farm manager, Doane Agricultural Service. Paul N. Doll, manager, Missouri Limestone Producer's Assn., was elected secretary-treasurer of the Section. The new Nominating Committee consists of D. D. Smith (chairman), P. M. Mulliken, and K. B. Huff.

Those attending the meeting enthusiastically supported a proposal that members of the Society in the states of Kansas and Nebraska join with their colleagues in Missouri to form a tri-state section. Steps are being taken to submit the proposal to A.S.A.E. members in all three states.

Personals of A.S.A.E. Members

Jack W. Austin recently resigned as advertising manager and as a member of the board of directors of The Sisalkraft Co., to personally direct the management and operation of his 355-acre farm along the Big Piney River near Palace, Missouri.

Sven O. Dahlgren recently resigned his position as district engineer for the U. S. Soil Conservation Service, to accept a position as civil engineer with a group of private engineers operating under the name of Panhandle Engineering Company with headquarters at Coeur d'Alene, Idaho.

J. H. Forby has been promoted from agricultural engineer to division manager of rural sales of the Public Service Company of Northern Illinois.

R. C. Hines, Jr., has resigned as extension agricultural engineer, Virginia Polytechnic Institute, to accept appointment on the staff of the agricultural engineering development division of the Tennessee Valley Authority.

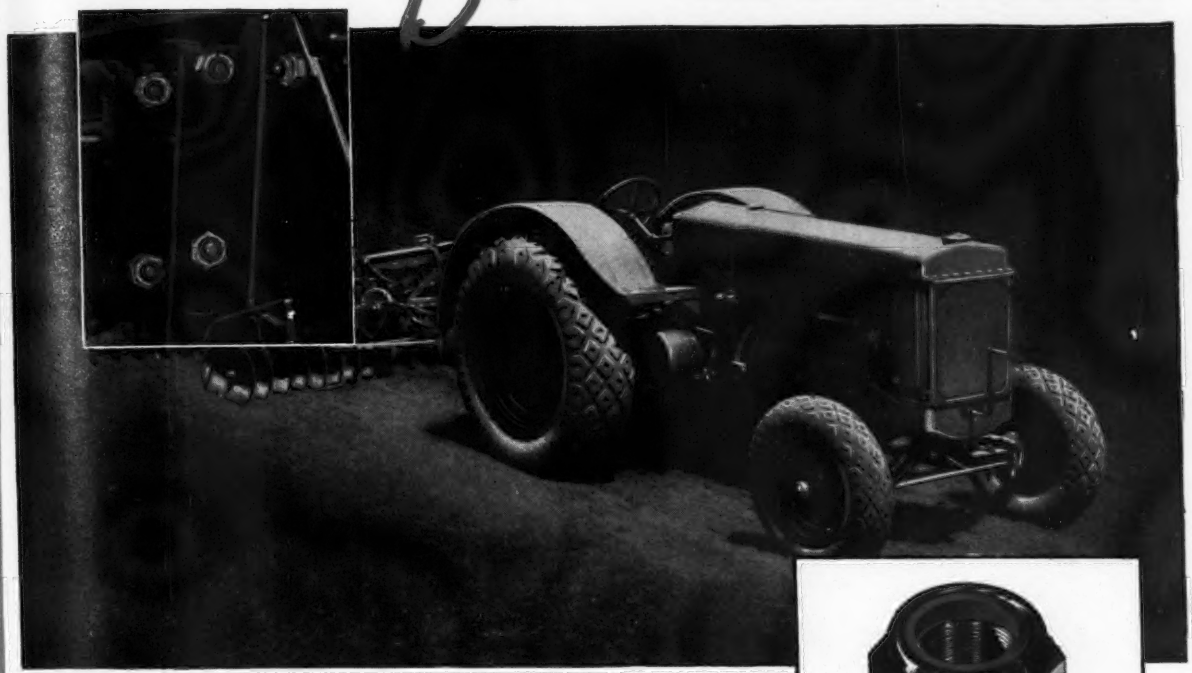
Paul W. Jenicek recently resigned as junior structural designer for J. F. Pritchard & Co., Kansas City, Mo., to accept a similar position with the Fluor Corp., petroleum refinery designers and contractors located at Pasadena, Texas.

Charles R. Little, formerly conservation and flood control engineer in the Ohio area for the Portland Cement Association, is now executive secretary of the Ohio Valley Conservation and Flood Control Congress.

Earle K. Rambo has been granted a year's leave of absence from his position as extension agricultural engineer for the State of Arkansas, to go to Panama to help formulate the farm power and machinery phases of that country's agricultural program. Mr. Rambo was chosen for the particular job in Panama by the USDA Office of Foreign Agricultural Relations, and he will be engaged in training Panamanian technicians in the handling of American-manufactured combines and tractors. His work will deal particularly with the technical problems of rice production, and he will study grain and bean storage facilities to devise methods of overcoming losses by weevils.

Howard C. Rutt has been promoted from division manager of rural sales to assistant to the manager of agricultural sales of the Public Service Company of Northern Illinois.

SELF-LOCKING *Prevents Breakdowns* FROM LOOSE FASTENERS



—the Red Elastic Collar provides dependable protection against VIBRATION!

Let's look at a draw bar connection. Its fasteners must hold tight against continuous vibration . . . permit easy removal for equipment changes . . . protect working threads against failure from corrosion . . . be reusable. Its fasteners must lock in position so that machine parts cannot loosen and wear out or break.

Draw bar and similar connections on all types of farm equipment need a fastener that can supply multiple protection against field breakdowns. Otherwise, the farmer will be penalized in terms of time, money and crop losses. And the dealer, in terms of free servicing and good will.

One fastener, the ESNA Elastic Stop Nut — with the self-locking, self-sealing Red Elastic Collar — provides dependable protection against Vibration, Thread Corrosion, Thread Failure, Liquid Seepage . . . and is Reusable! It meets all of the fastening requirements of hard working and weather exposed farm equipment. Elastic Stop Nut Corporation of America, Union, N. J.

LOOK FOR THE RED COLLAR THE SYMBOL OF SECURITY

It is threadless and dependably elastic. Every bolt — *regardless of commercial tolerances* — impresses (does not cut) its full thread contact in the Red Elastic Collar to fully grip the bolt threads. In addition, this threading action properly seats the metal threads — and eliminates all axial play between bolt and nut threads.

All ESNA Elastic Stop Nuts — *regardless of size or type* — lock in position anywhere on a bolt or stud. Vibration, impact or stress reversal cannot disturb prestressed or positioned settings.

ELASTIC STOP NUTS

INTERNAL WRENCHING

ANCHOR

WING

SPLINE

CLINCH

GANG CHANNEL

CAP

PRODUCTS OF: ELASTIC STOP NUT CORPORATION OF AMERICA

Applicants for Membership

The following is a list of recent applicants for membership in the American Society of Agricultural Engineers. Members of the Society are urged to send information relative to applicants for consideration of the Council prior to election.

R. B. Aakre, assistant professor of agricultural engineering, North Central School & Experiment Station, University of Minnesota. (Mail) 224 1st St., SE, Grand Rapids, Minn.

Vngve E. Andersson, chief research agricultural engineer, Swedish Institute of Agricultural Engineering, Ultuna, Uppsala 7, Sweden.

Frank W. Andrew, instructor in agricultural engineering, University of Illinois, Urbana, Ill.

Louis A. Bestgen, engineer and manager, Missouri Terracing Co., Tipton, Mo.

J. Wendell Blackketter, instructor in agricultural engineering, Oklahoma A. & M. College, Stillwater, Okla. (Mail) 407 N. Washington.

Thomas P. Christen, Jr., design engineer, Ohio Cultivator Division, National Farm Machinery Co-op. (Mail) 1275 Maple St., Mantor, Ohio.

M. E. Coleman, educational director, American Turpentine Farmers Assn., Box 889, Valdosta, Ga.

G. S. Dharan, agricultural engineer, William Sacks & Co., Ltd., 10 Clive St., Calcutta, India.

A. B. Emmerich, engineer, native land settlement dept., Swaziland Administration, Swaziland, South Africa. (Mail) P. O. Box 48, Mbabane.

Angus H. Franklin, veterans agriculture teacher, Florida State Department of Education. (Mail) P. O. Box 117, Bontifay, Fla.

Robert L. Granger, co-pilot, Delta Airlines. (Mail) 605 E. Temple Ave., College Park, Ga.

Clarence M. Hansen, assistant professor of agricultural engineering, Michigan State College, East Lansing, Mich. (Mail) 211 Elvin Court.

S. M. Najmal Haque, graduate student in agricultural engineering, Cornell University, Ithaca, N. Y.

Arthur C. Honnold, engineering dept., Wood Bros., Inc., Des Moines, Iowa. (Mail) Apt. 219, 1519 Grand Ave.

E. D. Knight, president, Virginian Electric, Inc., Charleston, W. Va. (Mail) P. O. Drawer 2833.

Frank B. Knox, student, Oregon State College. (Mail) 683 Laurel St., Junction City, Ore.

K. J. Kratz, factory representative (sales and research), J. I. Case Co., Rockford, Ill.

Norman E. Leach, agricultural engineer, Soil Conservation Service, USDA. (Mail) 309 E. Brin St., Terrell, Texas.

A. D. Mast, president, A. D. Mast Machine Works, 605 Marietta Ave., Lancaster, Pa.

Donald L. Maxwell, educational section, consumer relations dept., International Harvester Co., 180 North Michigan Ave., Chicago 1, Ill.

C. G. Pearse, assistant sales manager, J. I. Case Co., Racine, Wis. (Mail) 700 State St.

Paul F. Pippitt, farm terracing contractor, West Line, Mo.

Arthur W. Pohl, sales manager, Milsco Mfg. Co., 2758 N. 33rd St., Milwaukee 10, Wis.

Morris Reedy, agricultural engineer, Soil Conservation Service, USDA. (Mail) P. O. Box 176, Texarkana, Ark.

Ronald C. Reeve, irrigation and drainage engineer, U. S. Regional Salinity Laboratory, P. O. Box 672, Riverside, Calif.

John N. Reynolds, farm service consultant, Puget Sound Power & Light Co. (Mail) Route 2, Box 380, Kirkland, Wash.

Edwin R. Smith, president and general manager, Seneca Falls Machine Co., and owner, Poplar Point Farms, Seneca Falls, N. Y. (Mail) R. R. No. 2.

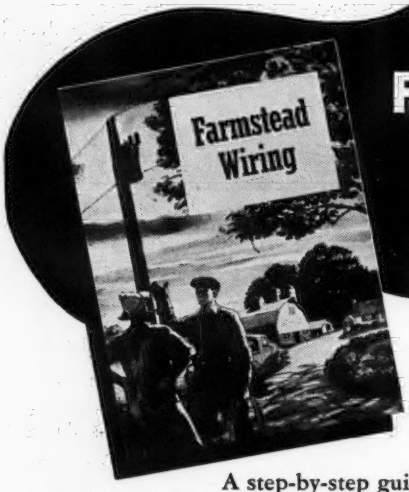
K. W. Westerberg, president, Farm Engineering Sales, Inc., Savage, Minn.

Albert N. Wold, agricultural enginer and sales manager, agricultural machinery division, Diamond Iron Work, Inc., and Mahr Mfg. Co., Minneapolis, Minn. (Mail) 2927 West 43rd St.

TRANSFER OF MEMBERSHIP GRADE

Hatto M. Berg, agricultural engineer, Soil Conservation Service, USDA. (Mail) P. O. Box 1031, Raymondville, Texas. (Junior Member to Member)

Frederick A. Brooks, professor of agricultural engineering and agricultural engineer in the experiment station, University of California, Davis. (Mail) R.R. 1, Box 334. (Member to Fellow) *(Continued on page 220)*



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PRICE 1 to 100 COPIES **25c each**

A step-by-step guide for planning a complete, modern electrical wiring system for farms . . . a system that will provide for present needs, as well as for future expansion.

Here's What People Say About It

A FARMER—*"It's just what I have been waiting for."*

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AN EDITOR OF A FARM IMPLEMENT MAGAZINE — *"This publication should have the widest possible distribution."*

AN AGRICULTURAL ENGINEERING EXTENSION SPECIALIST—*"Congratulations on assembling the information you have included in this book. It should be of real assistance to wiring contractors, inspectors and others engaged in farmstead wiring activities."*

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HOW TO PLAN

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You'll find it invaluable in planning any farm wiring installation.

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Farmers can make better hay Faster and at Lower Cost when they

Make it a Massey-Harris

THE first time you see one, you'll know that the Massey-Harris No. 6 Mower is the kind that farmers want . . . built to do good work and to cover more ground. Every nut and bolt, bar and brace, spells quality, performance, efficiency.

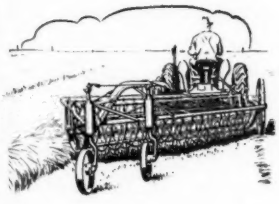
With its welded tubular construction, the No. 6 is ruggedly built. Husky roller bearings in the right places make it a light running, longer lasting mower. Guarded with safety shields, and an automatic safety release, it's as safe as any mower can be made.

But it's out in the field where farmers really appreciate the Massey-Harris No. 6. Simplicity itself to attach and detach — no lifting, pulling, or tugging.

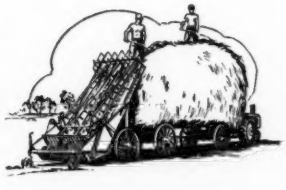
And . . . with its two caster wheels, one on either side, the No. 6 is literally a contour mower. It hugs the ground to do more uniform work . . . to cover more acres . . . to do a cleaner job of cutting . . . and with less wear and tear on cutter bar, pitman, bearings, and drive shafts.

There are plenty of reasons why more and more farmers are saying "Make it a Massey-Harris". A copy of the 1947 Buyers Guide gives you a few of them. Your Massey-Harris dealer, a good man to know, will give you more. See him for your FREE copy of the 1947 Buyers Guide, or write direct, Dept. ....

THE MASSEY-HARRIS COMPANY, ***General Offices:*** **RACINE, WISCONSIN**



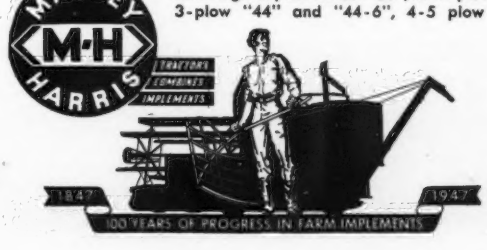
With its 4-bar cylinder, the Massey-Harris No. 11 Side Delivery Rake is built for big capacity at fast tractor speeds.



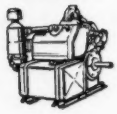
The Massey-Harris No. 8 Loader is famous for handling hay gently, an important factor in making high quality, leafy hay.

With a Massey-Harris Forage Clipper, a farmer can cut, chop and load any hay or silage crop in one easy, time-saving, labor-saving operation.

With five, great, new, post-war Massey-Harris tractors, there's a size and model for every farm! Light 2-plow Model "20", full 2-plow "30", 3-plow "44" and "44-6", 4-5 plow "55".



The FARM POWER LOAD
is Shifting More and More to
WISCONSIN HEAVY-DUTY
Air-Cooled ENGINES



Constant improvement in farm machinery and the development of new, ingenious equipment to lighten the farmers work-burden and increase the productive capacity of both men and machines, calls for an increasing use of self-contained power . . . in power packages not available through the tractor or rural electrification.
Wisconsin Heavy-Duty Air-Cooled Engines are participating in this modern phase of farm progress to a very considerable extent . . . because these engines have all the requisites for dependable, efficient farm service. Heavy-duty design and construction throughout, weather-proof air-cooling, light weight, extreme compactness, and a power range of 2 to 30 hp. (single cyl. and 4-cyl. types), adapts Wisconsin Engines ideally to a great variety of farm machines and farm jobs.

Most H.P. per pound
WISCONSIN MOTOR
Corporation
MILWAUKEE 14, WISCONSIN, U. S. A.
World's Largest Builders of Heavy-Duty Air-Cooled Engines

It's Hard to Imagine MEN WITHOUT WHEELS TODAY

If we had to go back to pre-wheel skids our civilization would wither.

WHEELS are VITAL

Give thought to WHEELS in each of YOUR DAYS. Loads must be transported — Speeds achieved — Safety maintained — Productive effort uninterrupted. Ergo — soundly engineered and skillfully produced MODERN WHEELS are essential. During more than a half century — since our organization originated the first all-metal wheels for agriculture — the name FRENCH & HECHT has symbolized PROGRESS in the designing, testing and fabricating of TRUSTWORTHY Wheels for a myriad of important duties. Mount your mobile equipment SAFELY — on French & Hecht Wheels.

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KELSEY-HAYES WHEEL COMPANY
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WHEEL BUILDERS SINCE 1888

Applicants for Membership

(Continued from page 218)

George H. Foster, assistant agricultural engineer (research), State College of Washington, Pullman, Wash. (Junior Member to Member)

James L. Gattis, extension agricultural engineer, State Extension Service, University of Arkansas. (Mail) P. O. Box 391, Little Rock, Ark. (Junior Member to Member)

Guy W. Halsey, territory supervisor, J. I. Case Co. (Mail) Box 1487, Roanoke, Va. (Junior Member to Member)

Max C. Jensen, associate professor of agricultural engineering, University of Idaho, Moscow, Idaho. (Junior Member to Member)

Curtis A. Johnson, assistant professor of agricultural engineering, University of Delaware, Newark, Del. (Mail) 306 E. Park Place. (Junior Member to Member)

William F. Lytle, research assistant in engineering experiment station, University of Illinois, Urbana, Ill. (Mail) 903 So. Busey. (Junior Member to Member)

W. E. McCune, agricultural engineer, Central Power and Light Co., 120 North Chaparral St., Corpus Christi, Tex. (Junior Member to Member)

Arch S. Merrifield, editor, "Farm Equipment Retailing," 1014 Locust St., St. Louis, Mo. (Associate to Member)

Paul M. Mulliken, executive secretary, National Retail Farm Equipment Assn., 1014 Locust St., St. Louis 1, Mo. (Associate to Member)

Sadao Nagata, farmer, Sugar, Idaho. (Junior Member to Member)

Robert A. Owen, soil conservationist, Soil Conservation Service, USDA. (Mail) Clarkesville, Ga. (Junior Member to Member)

M. D. Strong, farm manager, India Christian Mission, Champawat, U.P., India. (Junior Member to Member)

Wm. D. Test, training, Sears, Roebuck & Co. (Mail) 213 Evergreen Ave., Elmhurst, Ill. (Junior Member to Member)

Robert L. Walker, Lt. Co., Army Air Forces, USA. (Mail) c/o Military Science Dept., Ohio State University, Columbus, Ohio. (Junior Member to Member)

John W. Wolfe, assistant civil engineer, Soil Conservation Service, USDA. (Mail) LaGrande, Ore. (Junior Member to Member)

Ideas on Chemurgy

(Continued from page 187)

Attention was invited to the location in Oklahoma, near the source of raw materials for synthetic rubber, and near the center of the farm market, of one of the most modern rubber fabricating plants, now being devoted primarily to production of tractor tires and other items for farm use. Here is evidence of the growing importance and recognition of the specialized farm market for highly engineered operating equipment. It is also evidence of the growing variety of materials earning important place in the technology of agricultural engineering.

New Literature

HARVEST GOLD. Paper, 134 pages, 6 x 9 inches. Illustrated and indexed. The Texas Co.

A practical farm manual on lubrication and maintenance featuring chapters by well-known agricultural engineers as follows: "Tests Show New Rustproof Compound Saves Farm Machinery" by R. I. Shawl, "The Right Hitch" by A. W. Clyde, "Plows and Harrows" by A. A. Stone, "The Disk Plow and One-Way Disk Adjustments" by L. A. Hardy, "Care, Lubrication, and Servicing of Grain Drills" by F. R. Jones, "Corn Planters" by R. D. Barden, "Care of the Mowing Machine" by B. A. Jennings, "Ensilage Cutters and Harvesters" by F. D. Mayer, "Grain Binder Care and Adjustment" by J. W. Martin, "Corn Harvesting Machines" by Dr. J. B. Davidson, "Corn Picker Operation and Adjustment" by R. I. Shawl, and "Manure Spreaders" by Hobart Beresford. Supplementary information on a variety of related subjects is included.

WHAT BANKERS CAN DO ABOUT SOIL CONSERVATION. Paper, 35 pages, 8½ x 11 inches. Illustrated. Agricultural Commission, American Bankers Association, New York.

An introduction to soil conservation from a banking viewpoint, with chapters on the what, why, and how of soil conservation; answering questions bankers ask about soil conservation districts; making conservation equipment and trained personnel available to the farmer; bank loans for soil conservation; and what banks can do about it — developing community interest in soil conservation.

This Valuable Tool Saves Countless Hours

Here's the economical way to dig ditches, clean out clogged ones, drain wet spots or straighten crooked streams. Use dynamite! It goes where heavy machinery can't go, can be used at low cost when machinery is not available.

Atlas Farmex Ditching Dynamite is made especially for this work, to help you dry out your fields, save hours of labor and make your farming more profitable. It is strong, quick-acting, highly water-resistant, propagating.

For more details, write for our booklet describing the use of Atlas Explosives in agriculture, forestry and lumbering.

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Protecting Crops, Machinery, Homes
SISALKRAFT Does It

On farms — like any other business — every dollar saved is that much profit. Wind, rain, sleet, snow — exposure of every kind — can do much damage to harvested crops, machinery, buildings. With Sisalkraft much of this loss can be avoided.

Sisalkraft is ideal for temporary silos — emergency storage of grain — covering hay stacks — protecting machinery — curing concrete — lining poultry houses — protecting the home — plus many other uses. Costs little. Tough, tear-resistant, and waterproof. Can be used again and again.

Sisalkraft is sold through lumber dealers everywhere. Write for folders on Sisalkraft's many farm uses.

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A Message

to anyone whose problem is HANDLING CROPS FROM THE WINDROW

Innes Company welcomes every opportunity to supply special, built-in pick-ups to manufacturers of balers, forage harvesters, loaders — to anyone whose problem is handling crops from the windrow.

Innes is the oldest, largest exclusive manufacturer of windrow pick-ups in the world, with more than a quarter of a century of successful experience to put at your disposal.

The Innes Windrow Pick-Up has patented features, and has been developed into over 38 different models for various combines. No other pick-up can feature the piston action that picks up so gently, and automatically strips itself of weeds and vines. Innes is light, well-built.

Your letter will be answered at once.

Write

Innes Company

BETTENDORF, IOWA

Personnel Service Bulletin

The American Society of Agricultural Engineers conducts a Personnel Service at its headquarters office in St. Joseph, Michigan, as a clearing house (not a placement bureau) for putting agricultural engineers seeking employment or change of employment in touch with possible employers of their services, and vice versa. The service is rendered without charge, and information on how to use it will be furnished by the Society. The Society does not investigate or guarantee the representations made by parties listed. This bulletin contains the active listing of "Positions Open" and "Positions Wanted" on file at the Society's office, and information on each in the form of separate mimeographed sheets, may be had on request. "Agricultural Engineer" as used in these listings, is not intended to imply any specific level of proficiency, or registration or license as a professional engineer.

NOTE: In this Bulletin the following listings still current and previously reported are not repeated in detail. For further information see the issue of AGRICULTURAL ENGINEERING indicated.

Attention is invited to the desirability of checking on the housing situation when considering a new location.

POSITIONS OPEN: MAY — O-503. JUNE — O-506. AUGUST — O-510. SEPTEMBER — O-516, 520, 521. NOVEMBER — O-523. DECEMBER—O-526, 527, 531, 532. JANUARY—O-535. FEBRUARY—O-540, 541, 542. MARCH—O-543, 544, 546, 547, 548. APRIL —O-549, 550, 551, 552, 553, 555, 556, 557.

POSITIONS WANTED: FEBRUARY—W-207. APRIL—W-232, 237. MAY — W-309, 312. JUNE — W-316, 320. SEPTEMBER — W-337. NOVEMBER—W-358. DECEMBER—W-361. FEBRUARY—W-373, 374. MARCH — W-377, 378, 379, 380, 382. APRIL — W-383, 384, 385, 386, 387, 388, 389, 390, 391.

NEW POSITIONS OPEN

DRAFTSMAN—To develop plans in detail, with bills of material and labor estimates for construction of milking parlors, milk houses, barns, etc., for large farm equipment manufacturer in Midwest. BS deg in engineering. Must be competent draftsman with knowledge of structures. Actual experience in design, construction, and dairying desirable. Good opportunity for advancement. Single man would have better opportunity to find suitable living quarters. Initial employment on temporary basis, with excellent prospect for permanent employment for successful man. Age, 20 - 30. Salary $45 - $50 per week to start. O-558

MECHANICAL ENGINEER to head new division of mechanical engineering in a state college in a south central state. Work will include teaching and development of mechanical engineering laboratories. BS deg in engineering backed by general engineering experience. Teaching experience desirable but not required. Age, under 40. Salary, about $3000 (9 mo. basis) to start. O-559

ELECTRICAL ENGINEER to head new division of electrical engineering in a state college in a south central state. Work will include teaching and development of electrical engineering laboratories. BS deg in engineering backed by general experience in electrical engineering. Teaching experience desirable but not required. Age, under 40. Salary about $3000 (9 mo basis) to start. O-560

GRADUATE ASSISTANT in agricultural engineering, for half-time research on engineering applications in grassland agriculture, and half-time study for MS deg. BS deg in agricultural or mechanical engineering with farm background, good student with neat and orderly work habits. Employment on annual basis with one month vacation. Position open June 1. Arrangements can be made for man employed to take majority of graduate subjects in College of Engineering. Veterans allowed full subsistence. Salary $1200 (12 mo basis). O-561

CHIEF ENGINEER for general design, development and production of specialized farm equipment, including tooling and design of additional factory buildings and equipment. Location Nebraska. College background desirable but less important than actual experience and proper personal qualifications. Want progressive and aggressive production-minded man with adequate background in farming and farm equipment design, production, and testing. Organization, production, and sales growing rapidly. Some company controlled housing available. Age, 38- 48. Salary $4000 - $6000 plus bonus of $1000 to $3000, depending on qualifications. O-562

AGRICULTURAL ENGINEER to work with division rural service supervisor of an electrical utility in North Central area. Work will include rate and engineering matters on large electrical farm equipment installations, and assistance in general rural electric development in the division. BS deg in agricultural engineering. Experience in farm structures and rural electrification desirable but not essential. Sales ability, initiative and pleasing personality required. Excellent opportunity for advancement. Age, 22 - 35. Salary, $2400 minimum plus travel expense. O-563

TECHNICAL WRITER and service department representative to work with other departments and divisions of a tractor manufacturer in the midwest; to represent service department interests and policies in matters concerning the tractor; and to follow up owner complaints forwarded to the home office for necessary action. BS deg in agricultural engineering, with at least 3 years experience in farm machinery operation and service, and presentable appearance for company and dealer contact work. Opportunity for advancement to technical editor or assistant service manager. Age, 30 - 45. Salary open. O-564

NEW POSITIONS WANTED

AGRICULTURAL ENGINEER desires development, research, or project engineering work in the soil and water field. BS deg in agricultural engineering, University of Nebraska, 1944. BS deg in civil engineering, University of Nebraska, expected January 1948. Enlisted and commissioned experience in Corps of Engineers, U. S. Army. No physical defects. Available Feb. 15, 1948. Single. Age 24. Salary $3000. W-392

(Continued on page 224)

Time for a Spring Check-up . . .

on the plan that delivers Peace of Mind

THANKS to the work of patriotic volunteers, the U. S. Savings Bonds program has carried America a long way up the road to economic security.

During 1946, in spite of all the problems and uncertainties the nation faced, sales of Savings Bonds *exceeded redemptions* by $1,389,216,000. The success of this great sales operation has helped stem the tide of inflation, has reduced public debt holdings of the banking system, and has given millions of citizens a stake in their country and a profitable investment in their own futures.

Yes, we've come a long way—but the trip isn't over! Now is the time to check up on your Payroll Savings Plan. Make sure that all your new employees are familiar with its advantages. Remind *all* your employees that there's no easier, surer way to build their own futures—and America's—than by buying Bonds regularly through the Payroll Savings Plan. Every $3 invested pays $4 at maturity!

For any help you need in conducting the Payroll Plan, call on your State Director of the Treasury Department's Savings Bonds Division.

New Savings Bonds Plan won't affect the P.S.P.

SOON the Treasury Department and the banks of America will make it possible for farmers, doctors, and other self-employed people to participate in "automatic" Bond buying by special arrangement with their banks. This extension of the Savings Bonds program is not a partial payment plan and is intended *only* for people who are not in a position to take advantage of the Payroll Savings Plan.

The Treasury Department acknowledges with appreciation the publication of this message by

AGRICULTURAL ENGINEERING

This is an official U. S. Treasury advertisement prepared under the auspices of the Treasury Department and The Advertising Council

Cultivating a contoured field with Farmall A. Corn and hay are planted in alternate strips.

The Favorites Year After Year . . .

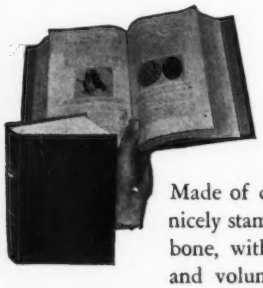
FARMALL TRACTORS

Farmers today want FARMALLS more than any other make of tractor. They know that with these versatile tractors they can carry out terracing, contouring and other soil conservation methods. In the Farmall System of Farming, there is complete equipment for every approved farming practice.

As new machines are designed by Harvester engineers for specific jobs, they are adapted to the Farmall System to bring every farming region the diversification and specialization of farm machinery it needs . . . to attain the best returns from the soil and increase farm profits.

INTERNATIONAL HARVESTER COMPANY
180 North Michigan Avenue CHICAGO, 1 ILLINOIS

A Handsome, Permanent Binder *for* AGRICULTURAL ENGINEERING



only $1.40

The ONLY binder that opens flat as a bound book! Made of durable imitation leather, nicely stamped on front cover and backbone, with name of journal and year and volume number, it will preserve your journals permanently. Each cover holds 12 issues (one volume). Do your own binding at home in a few minutes. Instructions easy to follow. Mail coupon for full information, or binder on 10-day free trial.

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Agricultural Engineers
Consultants on product development, designs, research, market research, public relations
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RATES: Announcements under the heading "Professional Directory" in AGRICULTURAL ENGINEERING will be inserted at the flat rate of $1.00 per line per issue; 50 cents per line to A.S.A.E. members. Minimum charge, four-line basis. Uniform style setup. Copy must be received by first of month of publication.

PERSONNEL SERVICE BULLETIN

(Continued from page 222)

AGRICULTURAL ENGINEER desires design, development, or service work in power and machinery field, with private company. BS deg in agriculture, 1943; in agricultural engineering expected May 1947, University of Wisconsin. Enlisted and commissioned service in Corps of Engineers, U. S. Army, plus farm experience and part-time work in agricultural engineering department, University of Wisconsin. No physical defects. Available June 1. Married. Age 26. Salary open. W-393

AGRICULTURAL ENGINEER desires sales or extension work in the power and machinery field, or project engineering in the soil and water field. BS deg in agriculture, University of Saskatchewan, 1947. Varied experience in summer work in farm machinery, soils, and farm management fields. No physical defects. Available May 15. Single. Age 24. Salary open. W-394

AGRICULTURAL ENGINEER desires sales engineering or service work in farm power and machinery. BS deg in agricultural engineering expected June 15, University of Tennessee. Commissioned service as pilot in AAF. Farm background. No physical defects. Available June 15. Single. Age 26. Salary open. W-395

AGRICULTURAL ENGINEER desires irrigation or drainage work, or development and extension work in farm structures. BS deg in agricultural engineering, June 1944; BS deg in civil engineering expected June 1947, University of Maine. Dairy farm background and Navy enlisted and commissioned service. No physical defects. Available July 1. Married. Age 29. Salary $3200. W-396

AGRICULTURAL ENGINEER desires power and machinery service work, or rural electrification. BS deg in agricultural engineering, Virginia Polytechnic Institute, expected in June. Farm background and Army enlisted experience. No physical defects. Available July 1. Single. Age 24. Salary open. W-397

AGRICULTURAL ENGINEER desires design or development work in power and machinery or soil and water conservation. BS deg in agricultural engineering, South Dakota State College, expected June 2. Farm background and part time work in tree nursery. No physical defects. Available June 2. Single. Age 26. Salary $2500. W-398

AGRICULTURAL ENGINEER desires power and machinery service work in private company, or rural electrification or extension work in a land grant college. BS deg in agricultural engineering, Clemson Agricultural College, 1945. Commissioned war service in U. S. Infantry. Power farming and county labor management experience. Leg wound, not disabling. Available May 1. Married. Age 28. Salary $2700. W-399

AGRICULTURAL ENGINEER desires sales or service work in the power and machinery field, or work in soil and water conservation. BS deg in agricultural engineering, A. & M. College of Texas, 1943. Enlisted and commissioned service in field artillery, including 15 mo. duty as motor maintenance officer. No physical defects. Available May 1. Married. Age 25. Salary $3000. W-100

AGRICULTURAL ENGINEER desires design and development work in farm power and machinery, design of farm structures, or field work in soil and water conservation. BS deg in agricultural engineering, A. & M. College of Texas, 1942. Farm background, eight years teaching experience and five years in design and manufacture of airplanes. No physical defects. Available on short notice. Married. Age 25. Salary $5000. W-101

AGRICULTURAL ENGINEER desires design and development in farm power and machinery. BS deg in agricultural engineering, University of Saskatchewan, 1940. Farm background, experience in irrigation engineering (3 yr), airport construction (1 yr), production engineer in machine tool manufacture (1 yr), RCAF aeronautical engineering maintenance (4½ yr), and design engineering on farm machinery (1 yr). No physical defects. Available on one month notice. Married. Age 30. Salary open. W-102

AGRICULTURAL ENGINEER desires agricultural engineering work in farm management or power and machinery service work. BS deg in agriculture with major in agricultural engineering, University of Florida, 1940. Citrus farm background, 18 months in Soil Conservation Service, naval air transport pilot, and commercial airline pilot. No physical defects. Available on 15 to 30 days notice. Married. Age 29. Salary $3000 - $3600. W-103